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They're No Angels

THE quality most sought in recruits to industrial concerns is the quality of being a good mixer. That is what Mr. Roy Lewis and Miss Rosemary Stewart found when they were gathering material for their fascinating book, *The Boss: The Life and Times of the British Business Man* (Phoenix House, 21*s*). Among the traits mentioned are: drive; decisiveness; determination; push; "toughness combined with civilisation"; analytical ability; an inquiring mind; ability to get on with colleagues.

We all know why it is desirable to be a good mixer in modern business, but as the authors point out, how many of the old giants would have satisfied this criterion? Such is the democratic climate of industry today, that the man who starts as a good mixer may be able to continue in that fashion right to the top. Like good civil servants, they make their mark in committees at successive levels, until finally they are directors of large industrial groups; as competent, as firm, and as accommodating as permanent under-secretaries. But these are not the giants of today. The giants are the men who, though they may have started as good mixers, end up by being good mixers only when they choose to be but at other times are withdrawn, or uncommunicative, or bristling, or like whirlwinds. And in changing their spots they grow less popular.

That is the book's basic theme—why are business men not generally appreciated, still less understood? After all, they ought to be given much of the credit for "taking the English labourer off a diet of oatmeal, bread, potatoes and a little beef or mutton, under leaky thatch, and putting him, as a Brylcreemed artisan, on to a diet of tinned and frozen foods in a modern council flat piped with electricity, gas and television."

He must satisfy the limitless expansion of human wants. It follows that he himself is under constant pressure to take a completely material view of life; we have pushed him there and he may tell us, like one American vice-president recently, that 10,800 dissatisfied Americans are born daily and "What's more, they're going to be dissatisfied every day of their lives. Whatever they have they are going to want more . . . 190 million dissatisfied Americans by 1965."

Can Britain, Lewis and Stewart ask, demand a continually higher standard of life and at the same time denigrate those who are expected to organise the increase? The answer is that Britain can and does. If she demanded the one but ceased to denigrate the other she might have achieved the same increases in productivity as America, but she would no longer be Britain. It is a healthy sign when we continue to place business men a good deal lower than the angels; we may hanker after a higher standard of life but we admit to ourselves that this is not the whole of us.

The business man must be a man of exceptional qualities. As a psychologist has said: it usually takes a long time to reach the top of any concern, and so the personality factors that drive a man upward must be consistent and sustained; he must have persistence. He must have a high degree of ability to organise unstructured situations and do so with decisiveness. He must have optimism and self-confidence. He works alone—even in secret—year after year, but he must not be thrown off his balance by that rather terrifying condition. In that respect he is like a soldier in high command.

Lord Montgomery's chapter in his *Memoirs* headed "My Doctrine of Command" reveals qualities which are remarkably akin to those which are demanded of the business man. Thus, "I hold the view that the leader must know what he himself wants. He must see his objective clearly and then strive to attain it; he must let everyone also know what he wants and what are the basic fundamentals of his policy. He must, in fact, give firm guidance and a clear lead. It is necessary for him to create what I would call 'atmosphere,' and in that atmosphere his subordinate commanders will live and work."

The big business leader, so Lewis and Stewart tell us, must have a capacity for keeping a substantial emotional distance from people which permits him to detach himself and move on—but not to another company, since studies have shown that the successful have rarely changed companies. Forty-one per cent of directors had remained in the same company and a further 31 per cent made only one change. The successful business man finds himself out on a limb, and he is not likely to come back and risk going out on another. He is, indeed, like the penguin who leads the flock from one ice floe to the next: whether he jumps of his own free will or whether he is pushed by the rest of us who are pining for better things (but take care to stay safely in the middle of the flock), he has somehow got to the front and he takes the plunge. When he gets us to the other side we let him get lost in the flock, because he makes us too conscious of our own shortcomings. We admire him, we envy him—but he is rather a bounder.

Cover Picture.—*A fitter is shown engaged on the erection of a 200 kVA transformer for installation at an NCB colliery. It will drop the incoming supply of 3,300 volts to 565 volts for distribution.*
(*Nurnberg photograph for* ENGINEERING

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Plain Words

"A building should be designed to fall down," said the young man across the table.

"And what," said I, "if you happened to be in it when it fell?"

"No, seriously," he continued, "if you built a house to stand up in all conceivable contingencies—earthquake, fire, flood and nuclear assault—it would cost so much you could never build at all."

"You," I remarked, "must be a builder with an eye for business—the more buildings that fall down, the more work for builders."

"Don't worry, I'm quite honest," he laughed. "I merely think it's time we started using our materials and other resources less wastefully. It's a line many civil engineers have been plugging for years."

"You mean Baker's stuff, plastic theory and all that? What about mechanical engineers with their cut-throat costing?"

"Sure, but it's still fundamentally the same idea: work out where it gives and then apply a safety factor that puts you roughly where you were. Far better to assess the contingencies, decide on an acceptable risk of failure and build accordingly. A bridge is bound to collapse in some situation, however well it's built, but if you increase the risk from one in a thousand million to one in a hundred million, you're still pretty safe, though you may save a lot of steel and concrete."

"You mean if five steamrollers and a herd of marching elephants crossed it in a gale, the bridge would collapse, but it would be all right with four steamrollers."

"You're getting warm, but you've missed the main point. The essence of the idea is statistical probability—the probability that all the unfavourable factors would be applied simultaneously. No-one can say with certainty at what point a bridge will fall down, but you can, on the basis of the available evidence, determine the probability of its failing within say 50 years. Some risk has to be taken whether you like it or not. Unfortunately, no customer would dream of awarding a contract to a firm that admitted there was any chance of their product blowing up or falling down."

"Can you blame him?"

"Frankly, yes. We can't afford not to take risks today. After all, when you decide to drive a tunnel through the Alps you know the chances are that you'll lose a few lives. But you still go ahead. We're passing from an age in which resources could be used liberally, even squandered, into an age when careful husbandry is the key to survival. Nowadays wastefulness is a bigger hazard than the calculated risks of engineering."

I began to see what he meant.

CAPRICORN

Weekly Survey

Consultants Cost Less

Powerful moves are being made in the United States to force public officials to use only Civil Service engineers in the planning and supervision of public works. Private firms of consulting engineers are in danger of being elbowed out. At meetings of state highway officials there has been serious discussion of the possibility of eliminating private firms in connection with the vast new Federal Aid highway programme.

Last week a man of great experience in these affairs spoke out sharply, warning that the day might come when "pretty nearly everybody will be working for the government—certainly not a happy prospect." It was the voice of Mr. Robert Moses—chairman of the New York State Power Authority, city construction co-ordinator for New York (where skyscrapers are being pulled down to make room for bigger and better skyscrapers), and a man who has had a lot to do with the St. Lawrence scheme.

If engineering planning and supervision are carried out by a state highway department, he said, the cost is as much as 16 per cent of the cost of construction but private consulting firms generally work for half that figure. Why the difference?—because "outside professional consultants can seek their fortune anywhere, regardless of restrictions; they can advance and reward at will; they can make it possible for exceptional men to become partners. Public business, on the other hand, suffers from mortmain from absurd residence and age restrictions, seniority systems, veteran and other preferences, uniform efficiency ratings which in any event cannot reflect either lively imagination or executive ability, all aimed to maintain a level of satisfied mediocrity and the democratic rule of the lowest common denominator."

Euratom as a Market

The recently signed United States-Euratom Agreement includes provision for a 1,000 MW prototype reactor programme, enough enriched uranium for 20 years and finance for a joint research programme over the next five years. Does this mean that so far as nuclear power generation is concerned the Six are to become a closed preserve of the United States both for research and as a market for reactors? The difference in the power objectives between the United Kingdom and Euratom is around 3,000 MW by 1965. Even allowing for the 1,000 MW agreed with the United States this leaves a fairly large margin within which to do business.

Although Britain is not in a position to offer subsidies to prospective reactor purchasers, we can offer a type on which considerable sums have been spent in development and research which has the further advantage that it can be built with local labour. There are eight power reactors completed or started in the Six Community countries. Between them they have an electrical capacity of only 650 MW.

Five of them are in France, and are of gas-graphite types. Belgium's reactor is of pressurised-water design and Italy has one under construction. In Italy in addition to the 200 MW Calder Hall type and 135 MW PWR type there is the World Bank project and two further projects (namely a pressurised-water type of 130 to 180 MW and one of 150 MW). Germany plans to build four or five stations in the next six years with a capacity of 500 MW. The Dutch are planning to build a 150 MW reactor in 1962. France has plans for 850 MW of gas-graphite reactors and a total power of 1,200 MW in the next six years.

In a recent talk Mr. A. C. Copisarow, Scientific Councillor at HM Embassy in Paris restated the view that Britain's opportunities in Europe in the long term would be far greater if only she took the lead in full-scale international technical collaboration. Certainly Britain has already taken certain initiatives as a member of ENEA. But this advice should be seriously considered in view of the danger of the Community's research and development programme becoming centred on American techniques.

Solomon's Strip Tease

Faced with strong political pressure from South Wales and Clydeside, the Government has tried to use Solomon's formula for the siting of the steel strip-mill project. The modern Solomon, however, has had to split the baby in two, and it is by no means unlikely that the baby, as would be expected, will suffer in consequence.

It has been decided that the project shall be divided into two parts, as had been generally expected. Richard Thomas and Baldwins Limited are to install 500,000 tons of sheet and tin plate capacity, while Colvilles Limited in Scotland will install an initial capacity of about 500,000 tons for sheet and light plate. The nett increase of capacity in Scotland is not likely to be as much as 500,000 tons, since it is intended to cover a modernisation scheme already approved. The Scots have not been slow to say that they have had the worst of the bargain.

In all the pressure which has been exerted both within the industry and outside it to reach a decision, the technical factors have been increasingly pushed into the background. The big market for sheet steel is in the Midlands, and South Wales is much nearer this market than Clydeside. Scotland's interest has been supported by the Government in the hope that new light-engineering factories will be attracted north of the border. Under modern steel-making conditions a plant has to have a capacity of not less than half a million tons to be efficient. It would be surprising if a more efficient unit could not have been built with a capacity of one million tons in one place. What has been lost in this compromise decision will never be known. Technical issues aside, the Scots are to be congratulated on a dogged and, in the end, successful campaign.

Local Liberty

Local authorities are being encouraged to go ahead with capital investment. This means that a number of housing projects and education schemes which had to be postponed fairly recently can now be put into operation.

The emphasis so far as the Government is concerned is on speed. They would like to see schemes put in hand which would make a quick impact on the employment situation and which could be finished off fairly quickly as well. It is likely that this encouraging push has been given in the hope that public investment will be considerably increased, and the emphasis on speed of termination may be something of a "red herring." If the Government wishes to emphasise the speed rather than the scale of the increase in public investment required, it could achieve this by stimulating the road building programme temporarily. It is as easy to stimulate road-building output by bringing in more road-making machinery (especially at the present time in Scotland and South Wales) as to open up new and ambitious building schemes for houses and schools. If the Government's intention is to force up the rate of capital expenditure (and so bring down the amount of unemployment) by the spring or autumn of 1959, they are likely to get a doubtful response from houses and schools.

Further indications that the Government are considering a complete change of policy on capital investment became apparent last week when Bank rate was reduced from 4½ to 4 per cent. On balance the Government is more afraid at the moment of deflation than inflation, and a big drive on the high level of unemployment is now obviously being mounted.

Coal Cut to Satisfy the User

For the Cadman Memorial Lecture to the Royal Society of Arts, Mr. H. A. Longden, Director General of Production, National Coal Board, and the President of the Institution of Mining Engineers, took the theme "Improving the Efficiency of the Mining Industry." After reviewing the history of mechanisation in coal mines he made the point that owing to the present shortage of large coal for the railways and for the household market it has become necessary to redeploy some of the most useful and productive machines, which, however, have a bad record as breakers of coal, and this has caused some loss of momentum in the drive for mechanisation at the coal face.

In support of this view he quoted some interesting figures for coal consumption in the USA over the ten years 1947 to 1957. These show that while consumption by electricity utilities rose from 86 to 157 million short tons, consumption by the railways fell from 109 to 8 million short tons, by industry other than the steel industry, from 132 to 98 million short tons and domestic sales from 97 to 38 million short tons. The rise in consumption for electricity generation was achieved in spite of the country's oil and natural gas resources and Mr. Longden thinks that the recent adoption of oil firing at some United Kingdom generating stations was justifiable only because a continuing shortage of coal was feared.

In this country the demand for large coal for the railways will decline with the growing adoption of diesel and electric propulsion, and the use of coal burning fires and stoves will probably decline though not to the same extent as in America. These losses, however, Mr. Longden expects to be made good in the expanding field of electrical generation and one of the main tasks of the coal industry will be to supply increasing quantities of the small coals required for electricity generation at progressively lower prices. This will require the fullest possible development of mechanised mining coupled with an extension of the system of payment by results based on the wider application of method study and work measurement.

Big Car Little Car

Despite the bold announcements by the American automobile industry to open up the small-car market, signs are not lacking that circumstances will force the industry to decide against it. Sales of the new season's large models have been encouraging so far. The American public seems prepared to pay rather higher prices for new models which in effect offer few innovations except an increased use of glass.

The American industry is aware that its public, its distribution and its production lines are big-car minded. The shift to smaller models involves in consequence a major upheaval not only in production policy but in distribution and public taste. For the industry to switch its production lines to smaller types is risky enough. With labour costs high and tooling-up for small models something of an adventure in techniques and cost estimates, there might be a disconcertingly small price advantage for the finished product compared with its big brothers. Added to these problems would be an overhaul in the distribution system and a heavy advertising outlay. There is a real danger that if the American automobile manufacturers become too easily dazzled by the volume of imports of foreign cars. For them it could be a marginal market without a profit margin.

There is, therefore, something to be said for the view that the foreign manufacturer, including British motor car manufacturers, has a big stake in the American recovery at the moment. It is an intriguing problem for the importer into the United States, as well as the United States manufacturer. Does American recovery mean a whole-hearted switch from small back to large cars? Or is there an assured market for the small foreign car for an indefinite period ahead?

Forth Suspension Bridge

At a ceremony at South Queensferry on Friday, 21 November, the Secretary of State for Scotland, Mr. J. S. Maclay, drove the first pile of the Forth Road Bridge. His action marks the end of thirty years of discussion. As one bystander remarked "All they have to do now is build it." Just what building it will entail can be judged from some of the bridge's statistics. The central span will be 3,300 ft long, the two main supporting towers 512 ft high, and the clearance above the river 150 ft.

The site chosen is about half a mile upstream from the Forth railway bridge. It has the advantage of enabling the submerged Mackintosh Rock to be used as foundation for the north main tower. The south tower presents a much more difficult problem. There it will be necessary to sink caissons into the river bed to reach a rock foundation. It is hoped to strike rock at 75 to 100 ft. The £2½ million contract for the first phase of the work has been awarded to the John Howard Company. It involves the construction of the foundations of the main towers, the erection of reinforced concrete side towers and the construction of the anchorages for the main cables. These will be formed by driving tunnels tapering from 25 ft to 40 ft square some 200 ft into the rock on both shores. Work began on 1 September and has gone farthest on the north shore. Here a causeway is being built out to the point on the Mackintosh Rock where the north tower will have its foundations. On the hillside a start has been made in driving the anchorage tunnels. On the south shore drilling is going on to determine the depth to which the caissons will have to go down.

The first phase is expected to take about two years, the building of the bridge itself, for which the ACD Company has an £8½ million contract, a further three years. Meanwhile, the Films of Scotland Committee together with Scottish Oils and Shell-Mex, announce that they are making a colour film of the building of the bridge. It is good news that what the committee calls "a complete record of the enterprise, from start to finish" is going to be available.

Money for Designs

Two competitions with attractive prizes for engineers were announced last week. For resolving London's road problem there is a first prize of £2,000. Still more lucrative is $15,000 for a steel highway bridge. If the sponsors of the first stand to get a lot for their money, the generosity of the second group should be an encouragement to bridge engineers.

It is the Roads Campaign Council who are seeking plans for a modern road system in London. Projects completed so far, in hand, or proposed are nothing more, they say, than attempts to provide localised relief. For a new appraisal that will enable a "concerted, effective and realistic attack" on the problem, the Council are offering three prizes—of £2,000, £1,000 and £500 and three more of £250. Full details and information regarding the London traffic problem can be obtained from the Council's offices, 15 Dartmouth Street, London, W.1, in return for a £2 deposit, which will be refunded on receipt of a *bona fide* entry or return of the documents by 7 April, 1959.

A total of 15 awards totalling $44,000 are being offered by the American Bridge Division of the United States Steel Corporation to stimulate the best use of steel in the design of bridges. Competitors will be required to submit drawings for an overpass structure in steel to take a two-lane highway at right-angles over a four-lane highway on level ground, the design being to American standards. Apart from the first prize of $15,000, there are additional awards of $10,000, $5,000 and five of $1,000. Students will be eligible in a separate competition for prizes together worth $9,000, the first valued at $4,000. Full details can be secured from the United States Steel Export Company at either 5 Queen Street, London, E.C.4, or 100 Church Street, New York 8.

Military Engineering

The current collection of the Parker Gallery, 2 Albemarle Street, London, W.1, is devoted to Military Prints, Paintings and Relics, and includes a section spanning some 150 years of the history of the Corps of Royal Engineers and its forebears. Among other prints, there is one showing a pick and shovel brigade in the '80's, and another, in a more elevated sphere of engineering, the balloon section during the Boer war. A print of the dress of the Royal Military Artificers in 1794 depicts an NCO apparently holding a survey staff, while two sappers are employed on masonry. Several prints show more or less primitive forms of Bailey bridge, while one, of the Royal Sappers and Miners in 1843, shows the embarkation of troops and ordnance by means of a pontoon.

Letters to the Editor

BETTER CRAFT APPRENTICES

SIR, I have been meaning to write to you on the subject of boys being kept on at secondary modern and technical schools until they are 18, mentioned in your open letter (ENGRG., 10 Oct. '58, p. 459).

I agree strongly with what you say. We look to these schools for our craft apprentices and encourage these boys to come to us as soon as possible after their 15th birthday. In schools which have both the workshop equipment and the teachers, some of these boys are able to have up to two years of quite useful bench and machine experience by that time and they come on quickly with us. These are the boys whom we expect to become our finest craftsmen.

I have not read the full text of what the Minister of Education said, but as he evidently went off the beam he probably was not dealing with the small number of boys who manage to get recognisable "O" level qualifications from these schools. If the school is able to teach English, history and geography, and to prepare these boys for the general paper we could accept them for training as student apprentices. But if the subjects which they take are technical then we think that the end product would almost always have been better to have left school at 15 and taken these subjects at technical colleges. This is particularly so in Sheffield where the teaching of English at almost all the schools seems to have run into desperate straits.

Where there may be schools which have both the teaching staff and enough boys to make up classes which would stay on to 18 years old this should not be entirely discouraged, but I take it that you think with me, that it would be better to transfer these boys to grammar schools at 14 or 15 years of age.

Yours faithfully,

T. A. O'NEILL.

Davy and United Engineering Co. Ltd.,
Darnall Works, Sheffield 9.
19 November, 1958.

Plant and Equipment

ELECTRONIC COMPUTER ELEMENTS

AT PRESENT, there are about 100 computers in use throughout Britain, about half of them working on scientific problems. At least another hundred are on order—these are mostly for commercial and industrial use. Thus, the Electronic Computer Exhibition, opening today, comes at the transition of computer application from the field of science to that of industry, from the laboratory to the shop or office floor. In these circumstances, the Business Computer Symposium is a particularly valuable adjunct to the exhibition: from 1-3 December papers will be read reviewing problems of applying computers to business and industry, solutions adopted in present installations, and plans for future, more ambitious, projects. It and the exhibition will together sum up for business and industrial management what has been done with computers in Britain, and will show firms what practical use could be made of a computer in their own factories and offices.

The exhibition, the first of its kind in Europe, has been organised by the Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association, at the instigation of the National Research Development Corporation. Details of the newer items of equipment on show are summarised below.

Output-Tape Punch

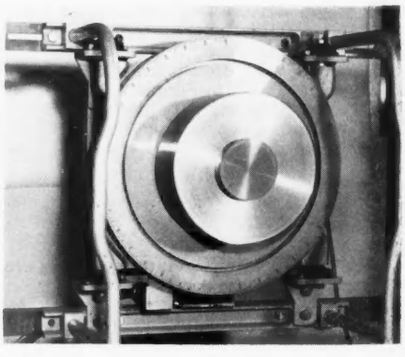
The model 3000 tape punch, designed for the direct recording of computer output data, is exhibited by Creed and Company Limited, Croydon, Surrey. With this machine, 5, 6, 7, or 8-track tape is punched at 300 characters per sec. The punch, shown alongside, is driven by an induction motor and operates on a multi-wire start-stop basis, with revertive signalling arrangements for input control. It is housed in a free-standing acoustic metal console, 38 in by 18 in by 42 in, which accommodates power-driven tape supply and winding reels, and an outsize cuttings box. Each of the individual punch pins is selectively controlled by an electro-magnet and the punching force is supplied by a motor-driven camshaft.

In this instrument, tape feed is selectively controlled by a pair of electromagnets, which actuate to control a pair of camshaft-driven feeding frames, each feeding frame being alternatively timed to advance the tape in a step-by-step manner.

The Creed paper punch machine punches tape at 300 characters a second.

Magnetic Drum

Sperry Gyroscope Company Limited, Great West Road, Brentford, Middlesex, are showing a magnetic storage drum illustrated on the right, which was developed in collaboration with the Automatic Telephone and Electric Company Limited. The reading and writing heads may be spaced axially along mounting posts and also adjusted circumferentially to any position around the drum periphery by means of a continuous T-slot in the mounting plate. The recording surface of the drum is nickel plating. Two versions of the drum are available at present, both of 9 in diameter. One has an effective surface area of 100 sq. in, the other, 157 sq. in. The surface finish is better than 16 micro-in and no surface defect exceeds an amount 8×10^{-9} of the total surface area. Maximum eccentricity or " run out " on the bearing spin axis, and the maximum non-linearity of the surface, are less than 0·0001 in.



The Sperry magnetic storage drum mounted on its carrying frame, with reading and writing heads removed.

Linear Position Indicator

A Helisyn position control is demonstrated by the British Thomson-Houston Company Limited, Rugby. The device, undergoing development, is for precision linear mechanical positioning in response to a numerical input; it has particular application in machine tool control and automatic inspection. A short cylindrical section moves along, but is not in contact with, a longer cylindrical section, each part being provided with conductive paths in the form of interlaced helices. One of the elements of the Helisyn is excited electrically by appropriate voltages set up in accordance with the input number; as a result, an electrostatically induced misalignment signal appears on the other element. In the exhibit, a laboratory apparatus accepts a decimal input defining position to 0·0001 in, and shows that the digital-analogue converter and Helisyn carries out positioning to an order of accuracy consistent with that of the input.

Potentiometer Drives

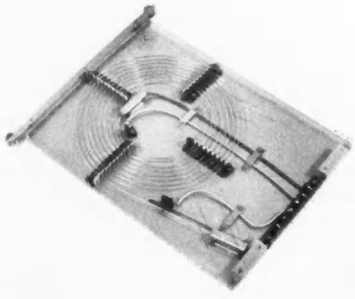
A working demonstration of the first of a range of potentiometer drive units is being given at the Kensington Palace Hotel by Kynmore Engineering Company Limited, 19 Buckingham Street, London, W.C.2, concurrently with the Computer Exhibition. The unit, which is suitable for driving from low power amplifiers, has been developed to provide computer manufacturers with a ready-made drive for servo-multipliers and is being supplied in quantity for the computers used in connection with the new nuclear power station at Hinkley Point. The unit consists basically of a micro-friction potentiometer with between 2 and 16 gangs, a sensitive low-inertia servo motor, and a precision gear assembly with involute gears—the inter-alignment accuracy being better than 0·15 per cent. The units are capable of a resonant frequency of 70 c/s with one volt r.m.s. input, that is, when the full characteristic of the special motor is exploited.

Transistorised Tape Reader

A high speed tape reader, shown alongside, is being exhibited by Elliott Brothers (London) Limited, Boreham Wood, Hertfordshire. It is designed to read standard 5, 7 and 8-hole punched paper tape at speeds up to 1,000 characters per sec, and can stop within a character. The characters are sensed by photo-transistors, which are illuminated via Perspex light guides. Tape is drawn through a pair of rollers, the upper roller being fixed on the end of a motor shaft, the position of the lower roller being controlled by an electromagnet. In addition, the tape passes between two flat surfaces, the pressure between these being controlled by a second electromagnet. This provides a braking action, which always overrides the action of the driving rollers. The transistors and light guides can be withdrawn in one unit, should a transistor require replacement. Transistor adjustment is effected through an inspection plate.

The Elliott tape reader reads punched tape at 1,000 characters per second.

Magnetostrictive Delay



A torsional wave magnetostrictive wire delay line with facilities for continuous adjustment of the delay period is displayed by Mullard Equipment Limited, Torrington Place, London, W.C.1. A line giving a maximum delay of 1 millisecond, shown on the left, requires 10 ft of wire but can be mounted in a unit of only 10 in by 7¼ in by ½ in overall dimensions. Lines giving maximum delays of any duration can be supplied. In a 4·5 millisecond line a p.r.f. of at least 250 kc/s can be stored, while with a 1 millisecond delay 1 Mc/s is attainable. The transducers consist of two coils connected back to back and mounted on a former that fits around the wire.

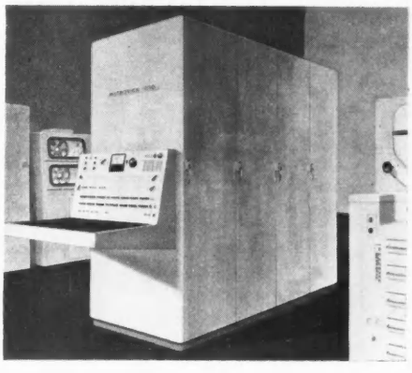
Adjustment of the delay is obtained by movement of the transducer along the line. The range of adjustment given by a single transducer is 100 microseconds, determined chiefly by the distance between the brackets supporting the wire. Addition of further transducers extends the range.

A 1 millisecond variable magnetostrictive wire delay line for p.r.f. up to 1 Mc/s, made by Mullard.

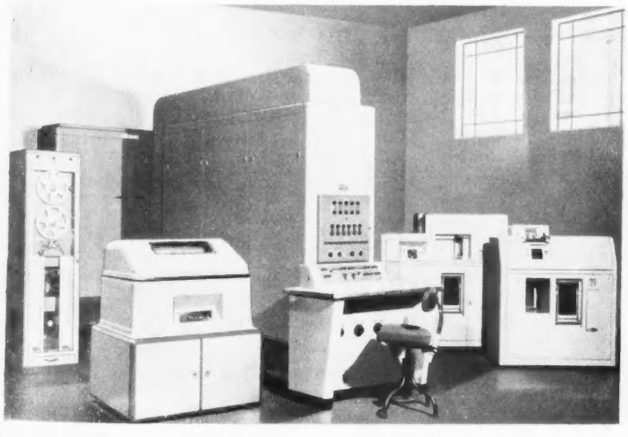
Metrovick 1010 Computer

Metropolitan-Vickers Electrical Company Limited, Trafford Park, Manchester, are exhibiting a model of their type 1010 data processing computer. The machine, shown alongside, is transistorised. The fast arithmetical and control unit operates in the parallel mode, and carries out typical data-processing programmes at a speed of some 50,000 simple address instructions per sec.

Both fixed-point and floating-point calculations can be performed. The ferrite core immediate-access store holds either 2,048 or 4,096 words. Word length is 44 digits and contains two 22-digit instructions. Auxiliary storage is provided by two types of magnetic drum and by magnetic tape. The 1010 employs a data scanner, which transfers information between magnetic core and ancillary equipment. The scanner interlaces the transfers automatically with the execution of computer instructions, and can maintain simultaneous transfer of blocks of data.



Artist's impression of the Metrovick 1010 data processing computer.



Data Converter

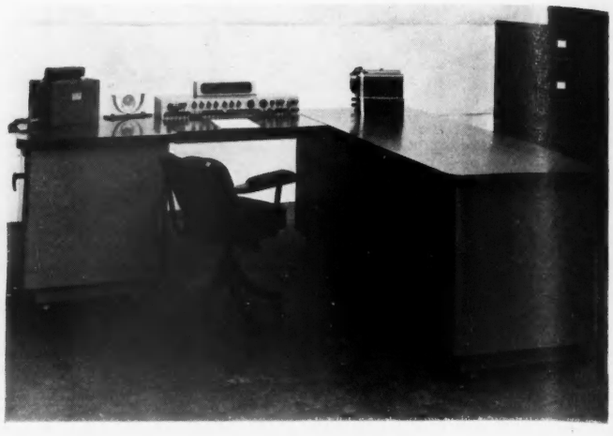
A converter is exhibited by Ferranti Limited, Hollinwood, Lancashire. The unit, shown on the left, is part of the full Pegasus data-processing system and makes it possible to transform information between punched cards and magnetic tape (either input or output) or from magnetic tape to a fast printer. While it is being used the computer is free to do other work. Eighty-column cards are converted to 16-word sections on magnetic tape; each column of a card is represented on magnetic tape by six binary digits. The distribution of the 80 columns of the card over the 96 character positions of the tape is carried out by means of a plugboard mounted on the reader. The card feed rate is 200 cards per minute. The reverse process is similar except that the card punching rate is 100 cards per minute. When the output printer is operating it prints a line of up to 92 character positions at the rate of 150 lines per minute.

A Ferranti data converter for transforming information between punched cards, magnetic tape, and a printer.

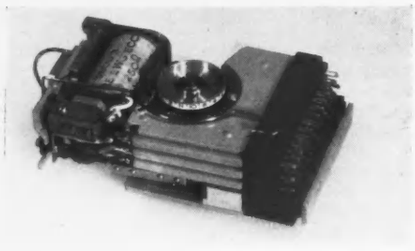
Continuing Electronic Computer Elements

Desk Computer

The National-Elliott 802 " Compudesk," shown alongside, is exhibited by the National Cash Register Company Limited, 206 Marylebone Road, London, N.W.1, and Elliott Brothers (London) Limited, Boreham Wood, Hertfordshire. It is a fully automatic stored programme electronic digital computer. The basic unit allows for punched paper tape input and output. Its store of magnetic cores has a capacity for 1,020 words of 33 binary digits, plus four words of fixed orders. The basic logical elements, which are standard, consist only of a magnetic core, a resistor, and a transistor, with printed circuit connections. Orders are of the single address type and there are two orders, of 16 binary digits each, per word of 33 binary digits. The extra digit is used for automatic modification of orders (B-modification). By means of this digit any location in the store may be used as a B-line. Digit rate is 166,500 per second. Multiplication requires 21·4 mS.



The Elliott 802 is a fully automatic stored-programme computer.



Miniature Uniselector

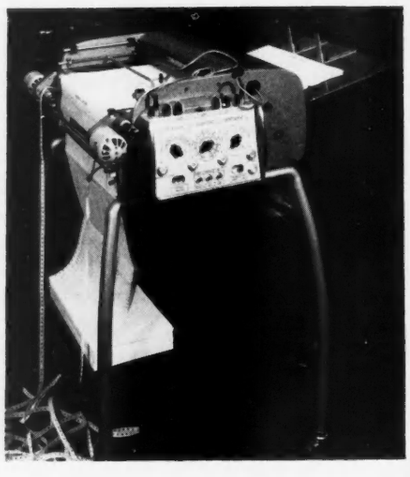
On the stand of Siemens Edison Swan Limited, 155 Charing Cross Road, London, W.C.2, is a miniature uniselector, shown left, which has been designed as a plug-in unit for mounting in the space of a Post Office type 3000 relay. It comprises a main mechanism, a contact bank, and a pre-wireable jack. An operational life of 2 million revolutions without readjustment is claimed. It weighs 12 oz.

Xerographic Printing

A new type of output printer, still in the experimental stage, is shown by Rank Precision Industries Limited, 33 Mortimer Street, London, W.1. The model shown prints at 1,500 lines a minute, but the intention is to increase this to 3,000 lines a minute. By coded instructions fed to a computer, the final printed form can be pre-determined. There are no moving mechanisms such as type bars—xerography is used.

High-Speed Guillotine

The Mathieu machine, shown right, a guillotine for separating continuous stationery, is displayed on the stand of Rank Precision Industries (sales being handled by A. J. Catlin Limited, Jasper Road, London, S.E.19). It can accept forms up to 19·5 in wide and separate them at up to 8,000 per hour, depending on the length, which can be varied from a few inches to up to 24 in, with control by a built-in photocell.



Data Transceiver

A data transceiver that allows direct card-to-card transmission over telegraph, telephone, or radio circuits is shown by IBM United Kingdom Limited, 101 Wigmore Street, London, W.1. The same units, shown left transmits and receives: a telephone transmission rate of 11 IBM punched cards per minute can be realised. An end-of-card check verifies that the whole card has been transmitted.

Built-in Tape Punch

British Olivetti Limited, 30 Berkeley Square, London, W.1, are displaying two machines incorporating an automatic tape punch: the Audit 322—an accounting machine; and the Audit 330—a billing typewriter. The tape is six-channel with rectangular perforations and no sprocket-feed track. The company also produce machines converting punched tape into punched cards or magnetic tape. The billing typewriter is derived from an accounting machine, and (with the exception of the calculating registers) preserves all facilities for entering and for horizontal and vertical programming. A direct mechanical linkage connects the machine to the punch, which consists of a coding unit, a punching unit, and a tape-feed mechanism. The punching unit consists of a set of punches (one for each channel) which are activated by the coding unit. The feed mechanism is independent of the punching mechanism.

Emidec 1100 Computer

The Emidec 1100, a high-speed computer, is being exhibited by EMI Electronics Limited, Hayes, Middlesex. The machine has a fixed word length of 36 binary digits. Automatic conversion to and from the binary code is provided with all peripheral units. Magnetic cores and transistors mounted on printed circuit cards are used, together with unit construction techniques. The immediate access store of magnetic cores can hold 1,024 words; magnetic drums of 8,192 or 16,384 words provide the main internal store. Any number of drums, within reasonable limits, may be used. High-speed magnetic tape decks with a tape storage capacity exceeding 13 million binary digits, or 2·5 million alphanumeric characters, with a read-write rate of 20,000 characters per sec, are also available. The clock rate is about 112 kc/s. Addition and subtraction require 125 μ-sec, and multiplication and division, 1·12 m-sec.

Fast Transistors

The OC23 and OC24—new alloy junction transistors developed for digital computers—are being shown by Mullard Limited, Torrington Place, London, W.C.1. The average cut-off frequency is 2·5 Mc/s and the collector dissipation, 8 W at an ambient temperature of 45° C (with infinite heat sink). For driving rectangular-loop ferrite devices, they provide 700 mA pulses of, for example, 2 μ-sec—with a rise time less than 0·5 μ-sec. The transistors have an extremely high slope—16 A per V—and give average current gains of 200 at 100 mA collector current and 150 at 1 A. Maximum emitter current is 1·2 A peak or mean, the maximum continuous collector-emitter voltage is 24 V (with a higher peak voltage), and the maximum thermal resistance is 3° C per watt. While OC23 and OC24 are almost identical, the OC23 is tested for certain ferrite-store drive circuits where it is important that the transistor does not alter the shape of the pulses.

The Human Element

Caves of Steel

Perhaps in the end no one will worry very much because there will only be one square yard for each of us to stand in, but at the moment there is furious controversy on the development and reshaping of cities. This is discussed in two articles in the November issue of *Town and Country Planning*, one on "Contemporary Residential Developments" in the United States, and the other, by Robin H. Best, on "The Loss of Farmland to Other Users in England and Wales."

Planners are divided into two warring camps on this issue. One group consider that there are "enormous social and economic disadvantages" in excessive size and concentration and that it is practicable to limit metropolitan expansion and density by planning controls. The others, many of them in the United States, do not believe that the growth of large cities can be controlled. It is inevitable, they argue, "a thing to be accepted and made the best of." They consider the crucial problem to be that of traffic congestion and that provision should be made for more rapid movement in cities, by means of new roads and highly organised passenger transport systems, coupled with high density apartment dwellings for great numbers of city dwellers of all classes.

The prospect of vast ant hills stretching for thirty to fifty miles and rising by the same number of storeys, is terrifying enough. But what of the erection of houses all through the countryside, the loss of agricultural land, and the long journeys to work, social entertainment and shopping? Is it best to resign ourselves to being essentially ants fed by a highly intensive farming system with the opportunity for week-end swarms (presumably, in time, "week-ends" will be "staggered" for lack of room) over the countryside or to seek the pleasant relaxing surroundings of our family houses in green setting? The answer need not come yet, for we have not reached this extreme. When we do the odds are heavily on the ant-hill solution.

Bid for Safety

A new emphasis is being laid on safety in all kinds of industrial settings in all kinds of countries. Building and civil engineering firms in the London area will have new facilities, in the shape of a Safety Training Centre for foremen and others in the building industry opened last week at the Government Training Centre, Enfield. This is a co-operative effort between Government and industry to cut down the accident rate on building and civil engineering sites. Last year, 16,000 accidents, including 185 fatalities, were reported. The London Building and Engineering Contractors Accident Prevention Group will run about six courses a year, each accommodating 30 students, which will be similar in character to those which have been run with conspicuous success at the Birmingham Industrial Safety Training Centre over the past two years.

The Russians also do it. They have safety inspectors, whose job it is to see that nothing is done against the rules, though in the past there has been a tendency to let safety take second place. An interview with Alexander Potemkin —a technical inspector employed by the Moscow Trades Council to check on safety measures in the Moscow underground railways' new building section is published in *Soviet Weekly* of 13 November. The routine is most businesslike and thorough and the claims typical Russian. "In recent years we've cut the accident rate to half while doubling speed of tunnelling. That's due to strict observance of safety rules." The capitalists do it with cash—Rubery Owen are awarding £300 a quarter for good factory housekeeping—a system of bonus marks and penalty marks awarded by a panel of judges who will tour the factory. For this purpose it has been divided into sections of 100 workers. The winning section will get a challenge cup and £3 a year.

Working Limits

The National Institute of Industrial Psychology has just completed a survey of six factories—two in engineering, two in textiles, one in mineral fibres and one in confectionery—analysing what people want out of their work. Nearly 1,700 employees recorded their comments. The booklet is entitled *Comments on the Job*.

Most people commented on organisation of work, especially on planning and progressing of work. The second priority went to pay. Poor ventilation was most often mentioned in working conditions. There was a good deal of comment about inadequate definition of responsibility and authority and about poor liaison between shifts and departments. Pay criticisms were mostly about differentials and incentive schemes. Training, promotion and transfer policy and methods were attacked often through ignorance though sometimes with justice.

Probably the most significant point of the investigation is the large number of people who wanted to get on with the job without hindrance. Although there was a good deal of criticism about incentive schemes, it may be that these influenced people's wish to get on with the job more than they were prepared to admit. There seems to have been a noticeable absence of comment about the congeniality or otherwise of workmates. Most seemed less concerned about the people they worked with than other surveys of this kind have suggested.

Putting Over Pensions

Quite independently of the new State pensions proposals and their impact on private pension schemes, the Pressed Steel Company have drawn up a non-contributory pensions plan for 17,000 workers. It provides free life insurance during employment, and free non-contributory pensions on retirement for all its factory workers.

The rate of pension will be decided for factory workers by years of continuous service up to 30 years. Normally a worker will be entitled to 1*s* a week for every year of continuous service up to 65. Staff already benefitting under the staff pension fund are also to get larger benefits. All can make contributions to the scheme to increase their own benefits if they wish to do so.

Special arrangements are being made to ensure that everyone is informed about the scheme. Management has been informed of the details in advance so that they can answer questions when the time comes and there have been special briefings at the company's four factories. Briefings took place at the same time to the same level of management in each factory. In this way 700 executives and supervisors have been confidentially informed about the scheme at 150 meetings. Full-scale meetings with the workers are to be held with insurance experts in due course. Further details about the method of introduction are available from the company.

Scholarship Bounty

Imperial Chemical Industries announce that last year 33 university students were able to change from arts to science courses by taking advantage of the ICI Transfer Scholarship Scheme. Of the 27 who took advantage of the opportunity in 1956 more than 80 per cent were successful and this is the reason which has persuaded ICI to extend its guarantee of scholarship funds for a further two years. These extend to five universities which originally co-operated in the scheme.

Birfield Limited have also announced university scholarship awards. Birfield University Scholarships will be tenable at any British university, and unsuccessful applicants will be considered for training by sandwich courses for the Diploma of Technology. There will be three scholarships a year from 1959. The training course will be in three stages—reading mechanical engineering at a residential university, an engineering apprenticeship for two years or a sandwich alternative and a staff appointment.

Hiring and Firing

An article in the latest issue of *The Supervisor* called "The Personnel Function" states that the employment office (that is to say the personnel department) is concerned with bringing together vacancies and candidates to fill them. The business of hiring (and also the matter of firing) belongs to the foreman as the representative of management.

Increasingly personnel departments are taking over the entire job of hiring and firing. The reasons for that are more complex than at first sight might appear. It is emphatically true that the tendency is helping to eclipse the authority of the foreman, which is regrettable. On the other hand, the growth in the power of personnel departments is part of the price we pay for persuading ourselves that the management of labour is a complicated problem involving social relationships, the reaction of people as individuals and as groups to their environment. Each clash on the shop floor or every job to be filled therefore takes on the appearance of a case study, a clynical experiment in human relations and so the experts (genuine and not so genuine) move in with their trappings of jargon and expertise.

These things are inevitable in a modern world which likes complications almost as much as progress. The answer is perhaps to rediscover the foreman, give him a new and synthetic-sounding name and clothe his essential functions on the shop floor with high sounding words. It could come.

Quietly Relax

So much has been said and written about subliminal perception—by which our senses may be confronted with a somewhat more insidious influence—that a serious account of the subject, such as that given in the October issue of the *Industrial Bulletin* of Arthur D. Little Incorporated is most welcome. It deals with experiments being carried out in the United States to assess how far people are exposed to certain kinds of stimuli (visual, aural, and so on) below the normal threshold of perception (subliminal influences). The evidence for subliminal perception—subception for short—has been carefully analysed and the results of experiments tabulated. The results are published in *The Journal of Psychology* for April, 1958, where J. C. Naylor and C. H. Lawshe of Purdue examined both theoretical and experimental grounds for subception. There is a "threshold" below which all perception is lost but this varies with the individual. The average threshold can be calculated but some individuals will be conscious of at least part of the messages. Moreover, emotional factors will influence perception. Lawshe and Naylor show that there is still far to go before arriving at the question whether a subliminal stimulus can affect behaviour. The more they probed the less evidence they found for either perceptual defence or subception. Meanwhile, their comforting conclusion is that "those who are worried about messages being beamed to the unconscious may relax for a while at least."

Special Article

ALL AVAILABLE INFORMATION

A report of the International Conference on Scientific Information, held at Washington, DC, USA, 16 to 21 November. The conference dealt with the use of scientific and technical information; the effectiveness of several methods of publication; the storage and retrieval of information; and the responsibilities of governments, professional societies, universities and industry for improving information services. Three of the main points raised were national and international organisation of information services, the acceptance of English and Russian as the international languages of science and technology, and the new machines for information handling.

THERE is a fruitful ferment of dissatisfaction with the way in which scientific and technical information is being handled in the industrial countries of the world. After the war, the output of material was being doubled every ten years: now it is being doubled at least every seven years. Some of the problems were examined by nearly a thousand delegates last week at the International Conference on Scientific Information. Though it was the first conference of its kind to be specifically labelled "international," it was really a full-scale follow-up of the conference on scientific information which the Royal Society held in London just ten years ago.

It will be very surprising if another ten years elapse before the next conference is held, because the comments of delegates from the USSR and Poland raised a point of fundamental principle which ought to be resolved quickly. The point was simply this: should the information centres (where information is collected, abstracted, stored and issued) be allowed to spring up freely as local circumstances and interests dictate, and under the aegis of any authority, private or governmental, which believes it can satisfy a need, or should there be a national centre for scientific and technical information in each country, serving all sciences and all industries? There was substantial support for the idea that international co-operation was required in order to reduce the cost to each country of handling the vast volume of literature. Even a country so large in resources as the USSR has difficulty in coping.

Many Americans felt that the Russian system savoured too much of bureaucracy; that the information workers would be too far removed from the scientists and engineers. Nevertheless, a few months ago the School of Library Science at Cleveland's Western Reserve University asked the National Academy of Sciences in Washington to shoulder the responsibility for setting up a national centralised office. The advantages of such an organisation will be apparent from a brief summary of the USSR paper, which was given by Dr. A. I. Mikhailov, director of the All-Union Institute for Scientific and Technical Information.

USSR INSTITUTE

The argument for establishing this institute in 1952 was that only a centralised system for issuing abstracts was thought to be capable of ensuring a more or less total coverage of information, "for only such a system affords the means for collecting, systematising and generalising all the facts dispersed throughout the multitude of sources." It was also felt that the system would avoid much duplication of effort.

Providing scientists and technologists with "exhaustive information on all the achievements in science and technology throughout the world—that is the stated purpose of the Institute." As the first and most important step, the Institute launched in 1953 the publication of an abstracts journal, which is now issued in 13 series, covering astronomy and geodesy, biological chemistry, biology, geography, geology, geophysics, mathematics, engineering, metallurgy, mechanics, physics, chemistry, and "electrotechnics." In some cases the Russian reader can take an abstracts journal in a more narrowly defined field. For example, the engineering series is available in five journals covering general problems of engineering and machine design, technology of machine building; metrology, measuring and control apparatus; technology and equipment for casting; transport, traction and hoisting equipment and engines; and branch machine building (whatever that may mean). The Institute also publishes "express information" bulletins on the more vital scientific and technical problems, and monograph reviews under the general heading "Advances in Science." Dr. Mikhailov concluded by saying that the object of his Institute was to make the abstracts journal into a kind of scientific forum for intellectual exchange between all countries.

POLISH SYSTEM

It would be foolish to assume that the Russians have an organisation which is without parallel in any other country. In Britain, for example, there are many research associations, professional societies, etc., which provide an abstracting and information service, and the same applies in the USA, where the network of information channels is very highly developed, though in neither country is there the same degree of centralisation as there is in the USSR. A delegate from Poland, contributing to the discussion, aroused interest in his country's system, because it appears to combine the best of both systems. The scanning and abstracting of the world's scientific and technical literature is carried out by some 80 specialist centres in Poland, and it is done by men who are practising scientists and engineers. They co-operate with many industrial establishments throughout the country—at present amounting to a few hundred but eventually to reach several thousand. At Warsaw a general headquarters controls the business of the abstracting system, divides the work among the centres, regulates standards of abstracting, and arranges the distribution and sales of the abstracts. From the point of view of an individual who has a query in connection with his work, the Polish system operates thus: if the file of abstracts cards in the works office fails to give the answer, he passes his inquiry to the appropriate information centre, who will usually be able to give him the information he is seeking; if not they communicate with an information centre in a country overseas.

There is a widespread desire for effective international co-operation. Dr. Alexander King, deputy director of the European Productivity Agency, remarked that no nation, however large, can be self-sufficient in scientific and technical information.

ENGLISH AND RUSSIAN

In Britain the Department of Scientific and Industrial Research would be fairly well placed to take the lead, but in the USA there is no one organisation which is obviously the most suitable body for the purpose. The most likely starter is the National Research Council of the National Academy of Sciences—a body which is a cross between our own Royal Society and DSIR.

It is not many years since Western observers predicted the stifling of Russian science by political direction and interference: certainly the Russians seemed to be making that mistake. But they have grown out of that. They have turned to a fairly objective approach to science and technology. They would like to see English and Russian accepted as the international languages of science and technology—a wish that is soundly based on the facts of the situation, and one that might be acceptable to a majority of nations speaking other languages. Dr. King believes that if international action is not taken on this question soon, within ten years or so, the opportunity will have been lost for ever, because Chinese will be on a par with English and Russian as a main language of science and technology. At present no organisation seems disposed to take action, though a lead may come when the lessons of the Washington conference have been assimilated. The best hope would seem to be for an *ad hoc* group of leading industrial nations (say the United Kingdom, USA, USSR, and selected European nations)—or rather the appropriate authorities of those nations—to get together. However, it would be practically impossible to enforce any such decision on a world-wide scale unless it was turned to practical use. That is where abstracts re-enter the picture; co-operation between those nations on abstracts, coupled with an agreement to publish the abstracts in English and Russian only, would have the desired effect—other nations would be obliged to follow suit, to everyone's ultimate benefit.

There are, however, many difficulties, including vested interests, which stand in the way of international co-operation. Dr. D. C. Martin, assistant secretary of the Royal Society, stressed the fact that such co-operation cannot be hurried. There must be a wider recognition of existing national bodies working in the information field, and full use must be made of existing machinery for co-operation. As far back as 1900, the Royal Society ran a service covering international scientific literature. It was discontinued in 1914 and was not resumed after the First World War mainly because, as Dr. Martin said, the growth of scientific literature had been so enormous. The Science Museum in London at one time kept files of papers and articles arranged by subject under Universal Decimal Classification numbers, but they got snowed under with the material.

NEW MACHINES

So the idea of an international organisation for scientific and technological information did not find much support. Somebody put the cost at perhaps $160,000,000 per annum. Already, it is estimated, the world spends about $200,000,000 a year on indexing and abstracting, and another $300,000,000 on searching or retrieval. The big question is how can these services be improved? And the tantalising background to this question is the fact that many new machines and techniques are looming up. The computers automatic data processing machines and other devices which have appeared in recent years—some shown at the conference were hardly beyond the prototype stage—hold out the promise of unbelievably high-speed retrieval.

In fact, one day this conference will be seen to have marked the point in time at which the designers of information machines and the users accepted the challenge which each put to the other. Already there are machines to, handle record cards, machines which automatically abstract scientific papers by taking out key words or sentences, translating machines, and experiments using the Monotype punched tape which is normally a waste product of setting the type for journals, books, etc. It is not too wild to think of storing in an electronic machine not just the librarian's keys to the information which is stored on his library shelves, but of storing the whole information directly in the machine. Certainly this operation can be carried out for limited fields of knowledge. How far will it go in the future?

Companies in the News

Testing Russian Tyres

Heenan and Froude of Worcester, acting as sub-contractors to David Bridge and Company Limited, who are members of the Rustyfa Consortium, are making eight full-scale tyre test plants for use in a Russian factory at Dneprodzerzhinsk. Two of these machines are capable of testing tyres by pressing them with a force of two tons each against a rotating drum. One of them, running at relatively slow speeds, is intended for the routine production and endurance testing of tyres and the other, rated for much higher speeds, will be used for research purposes. Three similar, but larger plants, capable of applying loads up to 5 tons per tyre, are likewise intended for routine testing and research purposes for tyres ranging from motor car to heavy lorry size. Two further plants are designed for the testing of "large giant" tyres and can apply pressures up to 15 tons.

The eighth plant is a "cornering force" machine. The tyre is placed in contact with a drum, rotating at speeds up to 120 m.p.h. and can be "steered" across the surface of the drum thus setting up forces very similar to those experienced on the road while cornering. Very close control over the detailed design of the plants is being exercised by Dunlop Advisory Services, consultants to the consortium, with the help of information supplied by Dunlop's own laboratories at Erdington.

Sweet Diversity

Of the two current fashions for fields into which manufacturing activities may be diversified, electronics seem to be gaining on nuclear equipment. The latest entrant are Blackburn and General Aircraft Limited, makers of the Navy's NA 39 bomber. They have set up a new organisation, with its own design and development departments, separate production facilities and separate marketing services. The manager of the new department is Dr. Harry Fuchs, who designed Blackburn's analogue computer and the servo-control mechanism for the high-speed wind tunnel opened by Lord Mountbatten earlier this year. Dr. Fuchs, who is only 28, took his B.Sc. in Physics at Manchester University and a Ph.D. in electronics at Southampton.

The company do not specify what type of electronic equipment will be made, but say that they will concentrate on equipment for industrial applications, such as data handling, control and instrumentation. The Blackburn Group's products now include gas turbines, building and civil engineering, mowers, rollers and agricultural equipment and motor engineering.

Tubular Strength

For the third successive year, Tube Investments Limited have produced record results. Trading profits at £12·58 million, after depreciation, for the twelve months to 31 July, were £605,000 more than the previous year. Their chairman, Sir Ivan Stedeford, commented that such results reflected a period of consolidation and, perhaps, "offered evidence that Tube Investment's widely spread, yet well-knit, range of manufactures provides firm ground on which to withstand many of the country's economic vicissitudes."

The growth of the fixed assets of the group has continued. During the year capital expenditure exceeded £5 million, but "the stringent monetary conditions in the autumn of 1957 and the prospect of falling demand" led to a fall in investment. Priority was given to projects for reducing costs, or adding new products to the group's range. Sir Ivan mentioned that "a notable feature" of the period was TI's growing contributions to the nuclear engineering industry. Ten years of research and development in this field, he said, is beginning to show a return. Emphasising the importance of new products and new techniques, he pointed out that a significant proportion of the present range of the steel tube division's products was either not made at all ten years ago or, at that time, represented but a fraction of the division's business. In his own words, "Sizes, lengths, shapes, specifications, pressures, materials, manufacturing processes—all have been challenged by the more stringent and increasingly intricate requirements of modern engineering, and the advances made in quality and technology have been impressive."

Apart from their steel tube division, the TI Group have a large electrical division, comprising Simplex Electric Company (cookers, spin dryers and water heaters), Mersey Cable Works, the Power Centre Company (cable trunking), and Gowshall Limited (street and road signs). All had a most successful year. Good results were also obtained by most of the dozen companies in the engineering and general divisions. Heavy plant sales in particular have increased (ferrous and non-ferrous rolling, wire drawing and mechanical handling plant) and additional capacity is being provided at the works of W. H. A. Robertson and Company at Bedford for even larger and heavier equipment. The only unsatisfactory feature of the group's operations were those of the cycle division. Sales were almost maintained, but the contribution to profits was very little. TI are now busy establishing themselves in India, Ceylon and South Africa. In the aluminium industry TI have associated themselves with Reynolds Metals Company of America in what is described as "an effective partnership." Reynolds TI Aluminium (jointly owned) are busy developing the potential for aluminium in the United Kingdom and have recently acquired an interest in Venesta Limited, one of the leading producers of aluminium foil.

Rope Ladder

A stimulating story of expansion is told in the house magazine of Martin, Black and Company (Wire Ropes) Limited in an article reviewing the first 25 years of their existence. Founded in 1933 by A. D. Martin and W. S. Black they began in a very small way—"in a small workshop in which were installed a few machines powered by a 30 h.p. diesel engine." The first steel rope was despatched to a neighbouring steel works in January, 1954. At that time the works covered 14,500 sq. ft; they now occupy 200,000 sq. ft and the whole output of 1934 takes little more than two weeks of the 1958 capacity. In 1937 the Speedwell Wire Company was formed to supply Martin, Black with adequate quantities of high-quality wire. In 1955 a Canadian company was established in Montreal, expanding into Toronto in 1957.

The company's history is typical of many hundreds of concerns which started with little more than the inventiveness and energy of a few men. In 25 years they have spent £350,000 on re-equipment and modernisation schemes. Exports have been expanded and now account for two-fifths of total output, to some sixty countries. The reasons for this spectacular growth, which has made Martin, Black—with Mr. Martin and Mr. Black still at the helm—among the leaders of the wire rope industry, are discussed briefly in their magazine. Foremost is the reputation for high quality, established right at the beginning. Next comes a highly developed customer consciousness, backed by efficient and quick delivery and by a highly developed technical service on the use of steel rope in various applications. These remain the hall mark of successful engineering endeavour in this country and the foundation of successful exports.

Megator in Pittsburgh

Progress by a British company in the United States always makes a pleasing story to write up. In this case Megator Pumps and Compressors Limited, of London, formed a subsidiary company a year ago in Pittsburgh. The intention was to distribute the Megator sliding-shoe pump which offers particularly valuable advantages in coal mining and steelworks applications. Most encouraging progress has been made, in spite of the trade recession and intense competition.

Among the many orders obtained are some by the United States Steel Corporation, who bought sliding-shoe pumps after extensive trials. Six pumps are currently in use in one mine of the Pittsburgh Consolidation group and among other users are the Duquesne Light Company, operators of the first American nuclear power station at Shippingport, Pennsylvania. The success of Megator pumps in American ships built in British and foreign yards provides a good introduction to the United States shipbuilding and shipping industries and very active representation has been established on the Atlantic seaboard.

The ability of this relatively small company to compete successfully, in a highly technical field, with well-established American firms in their own territory is encouraging indeed, and a bright example of what can be done in America.

Atomic Review

Notes and News

Safety Committee

A nuclear safety advisory committee, consisting of experts of the highest standing is to be set up by the Government, in connection with the Nuclear Installations (Licensing and Insurance) Bill, outlined in Atomic Review on 7 November.

Creusot and Westinghouse Get Together

It has been reported that Forges et Ateliers du Creusot have concluded a licensing and technical assistance agreement with Westinghouse Electric International for the construction of nuclear reactors. A consortium called Fromatome is to be formed capable of undertaking complete power-reactor projects. Westinghouse are specially experienced in the design of pressurised-water reactors.

Latina Power Station

Last week the foundation stone was laid for the nuclear power station to be built by the Nuclear Power Plant Company Limited at Latina, near Rome. Details of the plant are recorded below.

TECHNICAL DATA ON A 200 MW REACTOR

Reactor Core	
Core diameter	14·5 m
Core height	9·45 m
Number of fuel channels	2,980
Number of control rod channels	100
Channel diameter	105 mm
Lattice pitch	203 mm
Number of elements per channel	8
Total uranium in one charge	275 tonnes
Max. mean thermal flux in moderator	$2·3 \times 10^{13}$ neutrons per sq. cm per sec
Mean uranium rating	2·5 MW per tonne
Reactor heat output	705 MW
Initial conversion factor	0·83
Reactor Vessel	
Mean diameter	20·35 m
Thickness	90 mm
Number of openings	230
Maximum working pressure	13·4 atm abs
Total estimated weight	1,636 tonnes
Coolant System	
Number of circuits	6
Diameter of ducts	1,680 mm
Reactor gas inlet temperature	180° C
Reactor gas outlet temperature	390° C
Blowing power (total)	19 MW
Boilers	
Number of units	6
External dimensions	5·698 m dia. by 24·09 m high
High-pressure steam conditions	52·4 atm abs at 373° C
Low-pressure steam conditions	14·3 atm abs at 373° C
Main Turbo-Alternators	
Number and output	3 × 70 MW
Speed	3,000 r.p.m.
Feed water temperature	88° C
Net station electrical output	200 MW

Sixth in a Series of Consolidated Report On

POWER REACTORS

By

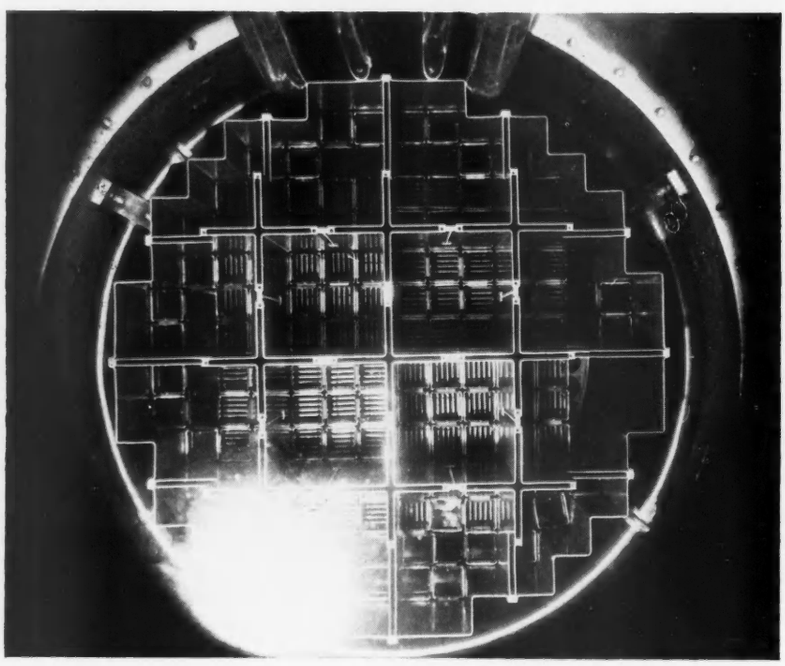
G. W. K. FORD, M.A.

Research Manager,

Dounreay

SINCE the last Geneva Conference many more reactor projects have been planned, and many of those then planned are now in commission and being further developed. The task of systematic and detailed cataloguing has become a project for organisations such as the International Atomic Energy Agency, and many excellent reviews of special aspects of the reactor programmes of various countries have been published elsewhere in specialist journals. Therefore our review of power reactors on the occasion of this Conference takes a rather different line and examines trends and highlights in reactor technology rather than attempting a detailed and comprehensive comparative examination of the proliferation of types and variants which now exists.

The overall picture can be seen from Table I (page 696), which classifies the most important reactor-types in terms of moderators and coolants, the order of tabulation having been selected so that the clockwise circulating arrows around the table indicate the general direction in which four important reactor parameters may be expected to increase. But it must be recognised that there are notable exceptions to the order indicated. For example, the highest coolant outlet temperature yet reported has been obtained with an air-cooled light-water moderated reactor operating an aircraft gas-turbine engine on open cycle (P465[1]), and there is much overlap in the core sizes, power densities and pressures. Nevertheless, the diagram does correctly indicatethe trends to be expected.



Core of the Experimental Boiling Water Reactor during critical fuel loading. Fuel was loaded in small increments, working outwards, until sufficient fuel was present to establish criticality.

Power Requirements

The world pattern of demand for nuclear power is not greatly different now from the situation in 1955: in Britain and Western Europe rising fossil-fuel costs and low capital costs are encouraging the early development of a large-scale nuclear power investment which has every expectation of being economic, if not immediately at any rate in the very near future. Russia has power shortages in some areas and this, together with less directly technical influences, is leading her to invest in a significant immediate power programme, both in the USSR itself and in satellite countries (for example, Czechoslovakia, P2092[2]).

In the United States, on the other hand, fossil fuel still remains cheap and there has not been the urge for the early development of a large-scale power programme. Interest has centred upon the exploration of a wide range of experimental reactor technologies, but includes a few immediate practical objectives, in particular the nuclear submarine. Nevertheless, a sizeable "demonstration" power programme has been launched to provide practical experience of nuclear power, which, although not destined to become an important fraction of the country's total power production as soon as in the United Kingdom, in absolute magnitude represents a considerable undertaking. Prominent among American reactors now operating is the Experimental Boiling Water Reactor (EBWR), which is illustrated on this page.

Reactor Types

The reactor types upon which the main interest is now focused are indicated in Table II (page 697): some 20 of perhaps over a hundred feasible arrangements. In all of them a coolant is circulated through the reactor out to an external heat utilisation circuit, and in a few advanced projects now in the design study or experimental stage the coolant contains the fuel in solution or dispersion and so is highly radioactive, or the coolant itself is highly radioactive as in the case of sodium. In the projects which are now being pressed forward for full-scale power schemes, however, this difficulty does not arise since the fuels are securely clad and the primary coolants (gases or water) do not become significantly radioactive except in the event of a burst fuel element. Intermediate in this respect are the boiling reactors but these do not present the same external circuit radioactivity problems as the circulating-fuel or sodium-cooled types.

Reactors may also be classified by their method of containment, and the diagrams on page 695 show pressure-vessel, pressure-tube and low-pressure reactor systems. Pressure tubes may be of straight-through or re-entrant design, and versions of the two approaches are shown on pages 698 and 699.

All the power reactors now operating, building or being designed convert their heat to work via the steam cycle, and indeed this system appears to have most of the advantages for large general-purpose nuclear reactor power plants (P273[3]). Doubtless there will be specific applications where, for example, such requirements as low weight, compactness, quick starting or freedom from water supplies will lead to the combination of the reactor with the gas turbine, and indeed one trial of such a system was reported at the Conference (in P465[1]). In this case the moderator was water (since a compact reactor was required), the coolant being air passed once through the system on open cycle and attaining an outlet temperature sufficient satisfactorily to operate an aircraft gas turbine.

A reactor more in keeping with such high temperatures (but which did not actually operate a turbine) was perhaps the United States Aircraft Reactor Experiment ARE) (P1075[4] and in ENGINEERING[5]) in which uranium fuel in solution in fused fluoride salts was circulated through a beryllia moderator block, providing an outlet temperature of some 850° C. This reactor was only operated for a few hours. In general, such very high temperature reactor-gas-turbine applications seem likely to be developed for small specialised applications such as small ships, aircraft and small mobile power plants rather than for stationary power-plant purposes.

The remainder of this article will therefore largely disregard systems of this category and examine in the main reactor systems intended for operation in combination with steam plant for stationary power-station duty. Specifically, referring again to the table, each moderator column will be taken in turn, starting with historically the oldest pile moderator, graphite.

Continued on page 696

On the 1958 Geneva Atomic Energy Conference

IMPORTANT REACTOR SYSTEMS CLASSIFIED IN TERMS OF CONTAINMENT

I. Pressure Vessel Types

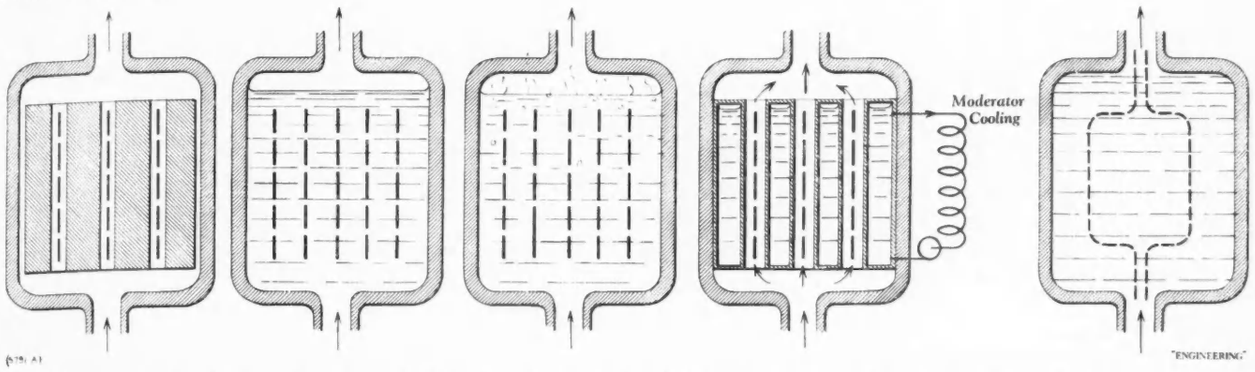


Diagram showing five typical arrangements of fuel, moderator and coolant in power reactors characterised by heavy pressure vessels.

(*a*) Type ve. Solid moderator (graphite) coolant gas (CO_2, He, etc.) in contact with moderator.

(*b*) Type vm. Liquid moderator, same liquid as coolant; e.g. H_2O, D_2O (~150 atm.) or organic liquid ~15 atm.).

(*c*) Type vm. Liquid moderator, boils to cool fuel; e.g. H_2O, D_2O (~40 atm.). Steam to turbine or heat exchanger.

(*d*) Type vi. Liquid moderator (D_2O) in calandria (Al, Zr), kept cool (60 to 80°C.); gas (CO_2 or He) or liquid (D_2O) coolant in thin tanks (Zr, Al alloy) insulated from calandria tubes (gas, D_2O, Mg O).

(*e*) Type vm. Homogeneous liquid fuel, one or two regions; e.g. D_2O (H_2O?). Circuit highly active.

II. Pressure Tube Types

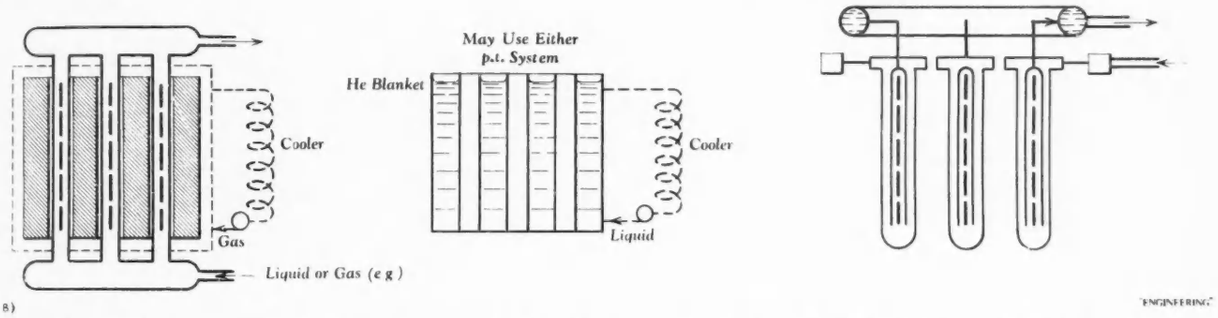


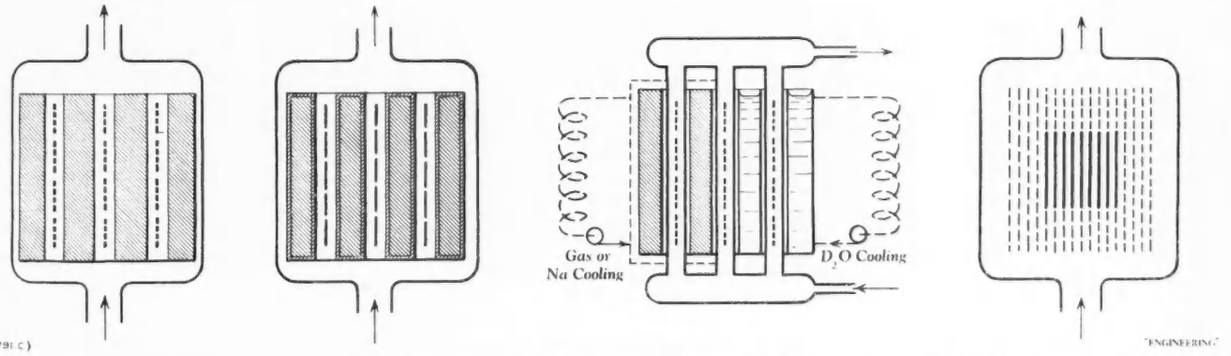
Diagram showing three arrangements of fuel, moderator and coolant in power reactors where fuel and coolant are contained in pressure tubes.

(*a*) Type t. Solid moderator (graphite or beryllia) cooled by separate system (gas, or Na for BeO) with liquid coolant (H_2O, D_2O) or gas (including steam) coolant. Through-type pressure tubes.

(*b*) Type t. Liquid moderator (D_2O) in calandria, cooled to below 100° C by external circuit (~7 per cent total power).

(*c*) Type t. Re-entrant pressure tube system (H_2O, D_2O, or Na at low pressure) may be used with (*a*) or (*b*) moderator. Eases expansion problems but introduces more material inside core.

III. Low Pressure Types



Arrangement of four reactor systems which operate at low pressure. Since the coolants are all highly radioactive, a well shielded primary circuit is essential

(*a*) Type lc. Solid moderator (graphite or beryllia); coolant in direct contact (e.g. U or Pu in liquid Bi if liquid fuel; Bi if fuel clad or Na with BeO).

(*b*) Type li. Solid moderator clad to prevent attack by coolant (e.g. Na coolant Zr-clad graphite moderator, stainless-steel or Zr cans).

(*c*) Type i. Solid (graphite or BeO) or liquid (D_2O) moderator, low-pressure coolant (Na) or liquid fuel (U in LiF) circuit. Could use low-pressure re-entrant thimbles as II (*c*).

(*d*) Type n. No moderator; fast-neutron system. Liquid-metal (e.g. Na) coolant.

GENEVA DISTILLATE

Prolific in papers and enormous in scope, the Second International Conference on the Peaceful Uses of Atomic Energy can only assume its true significance when the information presented there has been thoroughly digested. As a stage in this process, ENGINEERING has commissioned fourteen specialists to summarise the matter of the Conference under a number of subject headings. The process may be regarded as one of distillation, with concentrated fractions drawn off at various levels. The contributors have consolidated the information published during the Conference, selecting the essentials, reconciling the submissions of different authors and countries, and tabulating the most important data. As an introduction to the series, we published on 19 September Sir John Cockcroft's overall survey of the Conference. The present series is being published at weekly intervals and will include thirteen articles in accordance with the table. The Conference was held in Geneva from 1 to 13 September.

Power Reactors	Mr. G. W. K. Ford, Research Manager, Dounreay
Research Reactors (21 Nov., page 662)	Dr. V. S. Crocker, Reactor Division, Harwell
Thermonuclear Research:	
(Pinch Effect)	Dr. A. A. Ware, AEI Research Laboratory
(Other Devices)	Dr. R. J. Bickerton, Controlled Thermonuclear Research Division, Harwell
Propulsion .. (7 Nov., page 600)	Mr. B. T. Price, Reactor Division, Harwell
Radiation Shielding (31 Oct., page 568)	Mr. J. D. Jones, Reactor Division, Harwell
Engineering	Mr. R. P. Kinsey, Chief Engineer, Advanced Reactor Design Office, Risley
Metallurgy	Mr. L. M. Wyatt, Technical Manager, Risley
Instrumentation	Mr. R. B. Stephens, Mullard Equipment Ltd.
Nuclear Physics (24 Oct., page 536)	Dr. M. J. Poole, Nuclear Physics Division, Harwell
	Dr. M. Sowerby, Nuclear Physics Division, Harwell
Radioactive Isotopes (14 Nov., page 634)	Mr. E. R. Wiblin, Isotope Division, Harwell
Isotope Separation	Dr. F. I. Hurley, Head of Laboratories, Capenhurst
Chemistry and Processing	Dr. R. Hurst, Director, Dounreay

Continuing **Power Reactors**

Graphite Moderated Systems

Graphite is a cheap moderator compared with others except light water. For use with non-corroding coolants it can be used in direct contact with the coolants since it requires no container to hold its shape. It must be cooled to remove the 5 to 7 per cent of total fission heat generated within it, but is best operated as hot as practicable to self-anneal stored energy resulting from neutron bombardment (Wigner effect).

Gas Cooling

The first phase of the British nuclear power programme (P262[6]) is, of course, based on the gas-cooled graphite reactor, and reactors with nearly 1,000 MW of heat output per core are now building. Here the coolant gas is in direct contact with the solid moderator and hence must not react with the graphite. The reactor cores are large (up to 50 ft in diameter) and therefore require to be contained in correspondingly large pressure vessels. The highest attainable pressures are required to provide good heat-transfer conditions, the limit being set by pressure-vessel construction considerations. Using 3-inch steel plate, about 13 atmospheres can be attained in the large power stations now building (P73[7]), but in the smaller high-temperature reactors now being developed (P312[8]) a pressure of some 18 atmospheres is contemplated.

The thermal efficiency is limited, and thus the capital cost of steam plant is penalised, by the use of (*a*) magnesium (alloyed) as the fuel canning material, which permits a maximum operating temperature of about 425° C for the fuel cans and some 350° C for the gas outlet temperature, and (*b*) uranium metal for the fuel material, which again limits the maximum operating temperature and in turn the heat extraction rate due to limitation of maximum permissible temperatures at the centre of the fuel by the alpha-beta phase change (660° C) of the metal. For many types of reactor, therefore, attention is now turning to ceramic fuels, in particular sintered uranium oxide, and improved fuel cladding materials. For economic, low-enrichment reactors stainless steel is unattractive on account of its high neutron absorption, and much development effort is being spent upon beryllium and zirconium. This is expected to lead (P312[8]) to can temperatures of about 600° C and coolant outlet temperatures of 500° C to 575° C.

The United States is also considering a gas-cooled system (P450[9]). In this design study (ORNL-GCR-2), it is proposed to use helium as the coolant, enriched uranium oxide fuel and stainless-steel fuel cans. The chemical inertness of helium and the excellent high-temperature properties of stainless steel and uranium oxide are expected to enable very high gas outlet temperatures to be attained (providing steam temperatures of about 500° C) without damage to the graphite, and although the use of stainless steel entails enrichment of the fuel to offset the neutron absorption this is claimed not to be entirely an economic disadvantage, since it enables a higher power density to be attained and hence a smaller investment cost per installed kilowatt, and also provides other incidental advantages. In fact, the ORNL paper claims that there is no substantial fuel cost penalty associated with a properly designed enriched reactor.

Another interesting claim made in P450[9] is that "high-pressure gas may make possible heat fluxes and power densities comparable to the best liquid-cooled reactors now in operation"; and it goes on to suggest that although hydrogen is a difficult gas to handle, because of its excellent heat-transfer properties serious consideration should be given to developing its application as a coolant. The authors also conclude that at present "gas-cooled reactors are economically competitive with the best pressurised-water reactors available in the United States."

Air cooling is used for the open-cycle heat recovery plant of the French G1 reactor (P343[10]), but it would not be possible to use air cooling with a high coolant outlet temperature on account of oxidation of the graphite, and air as a coolant is probably only of interest for open-cycle applications using special high-temperature materials, such as stainless steel, in projects where neutron economy is of minor significance.

Water Cooling

The first Russian atomic power station was cooled convectively by pressurised water. This entailed passing re-entrant stainless-steel pressure tubes through the graphite moderator, which made it necessary to enrich the reactor. The water itself contribute significantly to both neutron moderation and absorption. No other country now appears to be interested in water-cooled graphite-moderated systems, but in the USSR this system has been further developed (P2183,[11] also P2139[12]) to one in which the boiling condition is established, the steam so formed in one set of pressure-tubes being used to raise steam in a secondary circuit, this steam being subsequently super-heated in a second set of pressure tubes. In the 100 MW (electric) design now under construction the pressure tubes will be initially of stainless steel, but when sufficiently developed it is intended to employ zirconium. The fuel will be 1·3 per cent enriched uranium alloy and deliver superheated steam at between 480° C and 535° C, thereby attaining a "unit efficiency" of 35 to 37 per cent. The use of a graphite-moderated reactor, or part of a reactor, directly to superheat steam is an interesting possibility but requires neutron-absorbing pressure tubes to prevent a "water-gas" reaction with the graphite, whereas carbon dioxide or (for high temperatures) helium gas does not require to be isolated from the moderator and may produce good superheating conditions in a gas-steam heat exchanger.

Liquid Metals

Two liquid-metal cooled graphite-moderated systems are still receiving serious consideration, namely the sodium-graphite system, upon which a successful and promising reactor experiment is now in progress (SRE: see P452[13]; Hallam, Nebraska: P2447[14]), and the molten-bismuth Liquid Metal Fuelled Reactor system (LMFR: see P461[15]). The latter is now being considered as a potential plutonium burner on account of its ability to burn plutonium without the need for intermediate re-fabrication of the exceptionally highly radioactive long-irradiation plutonium isotope equilibrium mixture.

The sodium-graphite reactor is perhaps mainly of interest in regard to its potential as a thorium burner working on the Th232-U233 conversion cycle, exploiting the high-temperature potentialities of sodium, thorium metal and graphite. The snag in this system is the need to keep the sodium out of the pores of the porous graphite, to avoid neutron absorption by the "soaked-up" sodium, and to guarantee freedom from chemical attack of the graphite by the sodium, although in fact there is little evidence of any attack by sodium upon graphite. This isolation is attained by cladding the hexagonal graphite blocks in zirconium sheet, and this in turn sets a limit to the sodium outlet temperature (about 360° C) which may be attained on account of corrosion difficulties. The fuel is clad in stainless steel and, using thorium, outlet temperatures of 650° C could be contemplated were it not for the zirconium limitation. Construction of a full-size station in Nebraska, began this summer.

Heavy Water Moderated Systems

Much interest continues to centre around the use of heavy water as a moderator. Its principal advantage is its exceptionally low neutron absorption cross-section and the possibility of operating the moderator at a comparatively low temperature, resulting in a further gain of reactivity from two main sources: (*a*) the considerable reduction of the migration length, with consequent increase in buckling value (M^2 can be reduced to almost two-thirds), and (*b*) by improving the value of η, the number of neutrons produced per fissile nucleus consumed (especially in the case of fissile plutonium). These properties make heavy water a very promising moderator, both (1) for the burning of natural uranium (as advocated by the Canadians, see for example P183[16]) with very long attainable burn-up (8,000-10,000 MWD per tonne) before reactivity is reduced so far by fission-product poisoning and fuel depletion (U235 and bred

TABLE 1.—*Classification of Important Reactor Types in Terms of Moderator and Coolant, showing Directions in which Four Significant Parameters may be Expected to Increase*

Temp. °C (↑ Trend to increasing coolant outlet temperatures (°C))	Coolants ↓ / Moderators →	G	D_2O	BeO / Be + G	H_nC_m*	H_2O	None	Pressure range, Atm. gauge (↓ Trend to increasing coolant pressures (atmospheres gauge))
	Power density kw/litre (Trend to increasing core power densities (kw/litre) →)	0·5–5	2–40	~ 5	~ 30	~ 75	100-1,000	
650–800	Fused salts			E i l 15				
500–700	Liquid metals: Na	E i l i 1	D i l 8	D i l 16			B l 21	0·5–6
	Liquid metals: NaK						E l 22	
	Liquid metals: Bi (L.F.)	D c l 2						
~400	H_nC_m		D t 9		E v m 17			~ 13
350–575	Gas: He	D v c 3					? 23	7–25
	Gas: CO_2	W v c 4	B t 10					
	Gas: Steam	B t 5	P t 11					
	Gas: Air	(E) c 6				E t 18		
250–300	Water (D_2O): Liq. fuel		E v m 12					
	Water (D_2O): Convect		B t 13					30–70 (b)
	Water (D_2O): Boil		B v m 14					70–150 (p)
	Water (H_2O): Liq. fuel							
	Water (H_2O): Convect	W t 7				W v m 19		
	Water (H_2O): Boil	B t 5				W v m 20		
		10^6–10^4	10^5–10^4			10^4–10^3	10^3–10^2	

(← Trend to increasing core bulk (litres))

Key to Symbols

v = pressure vessel.
i = coolant must be isolated from moderator.
t = pressure tube needed to contain coolant.
c = coolant in direct contact with moderator.
m = liquid coolant may rise with similar liquid moderator, but may be regionalised.
l = "low pressure" containment for coolant circuit and core.
b = boiling, p = pressurised.

Letters signify one or more reactors in category indicated:
W = Working as power plant.
E = Operating as heat-producing reactor experiment.
B = Power plant or heat-producing reactor experiment now building.
D = Detailed design studies in progress.
P = Possible future system being seriously considered.
? = Interesting possibility.
( ) = Early experiment or trial of small direct future significance.

* : H_nC_m means hydrocarbon, usually polyphenyls.

TABLE II.—*Principal Reactor Types Classified by Moderators*

No.	Country	Paper	Name	Coolant	MW (heat)	State	Remarks
Graphite Moderator							
1	USA	452[13]	SRE	Na	21	E	Operating at Santa Susana
	USA	2447[14]	Hallam	Na	N225	B	Construction begun in Nebraska
2	USA	461[15]	LMFR	Bi	—	D	Now proposed as Pu burner
3	UK	314[27]	HTGC	He	10	D	Reactor experiment projected
	USA	450[9]	GCR2	He	687	D	Enriched fuel, SS cans
4	UK	—	Calder	CO_2	200	W	3 working, 1 building
	UK	—	Ch. Cross	CO_2	200	B	1 critical, 3 building
	UK	73[7]	Berkeley	CO_2	555	B	2 reactors
	UK	,,	Bradwell	CO_2	531	B	2 reactors
	UK	,,	Hunterston	CO_2	535	B	2 reactors
	UK	,,	Hinkley	CO_2	966	B	2 reactors
	UK	312[8]	AGR	CO_2	100	D	To be built at Windscale
	France	1137[94]	G2, G3	CO_2	200	W	Pu producers at Marcoule
	France	343	EDF1, 2	CO_2	~ 240	B	Chinon 360 lb per sq. in
5	USSR	2139[12]	—	H_2O and	~ 400	B	Boil in one set tubes, S/H in another
	USSR	2183[11]	RAPS	H_2O and steam	~ 20	E	Original RAPS adapted for boiling and S/H
6	France	1132[95]	G1	Air	35	(E)	Heat recovery only, Pu plant
7	USSR	2183[11]	RAPS	Water	~ 20	E	Developed to boiling at S/H condition
Heavy Water Moderator							
8	USA	—	SDR	Na	40	D	Not referred to at conference
9	Canada	210[22]	Studies	Organic	~ 100?	D	Of possible interest for small plants
10	USSR	2053[26]	HWGC	CO_2	590	B	Czechoslovakia. Of wide interest
	UK	262[6]	HWGC	CO_2	—	D	British design studies are in hand
	France	343[10]	HWGC	CO_2	—	P	France may be interested
	USA	—	Florida	—	~ 150	D	Power demonstration
11	—	—	HWSC	Steam	—	P	A possible alternative to CO_2
12	USA	449[25]	HRE-2	D_2O	5	E	Advanced project, radioactive coolant.
	USA	—	Pa Power	D_2O	~ 600	D	Single-region slurry
13	Canada	209[17]	NPD-2	D_2O	~ 80	B	Pressure tube power demonstration
	Sweden	135[37]	R3	D_2O	65	B	Electricity and district heating, Agesta
	Sweden	136[38]	ADAM	D_2O	75	B	District heating, Vasteras
	USA	610[16]	Studies	D_2O	~ 450	D	Studies of four main variants
	Switzerland	246[19]	Sultzer	D_2O	~ 24	D	For Zurich
14	Norway	559[21]	Halden	D_2O boil	10	B	Reactor experiment, boiling
Beryllium Moderator							
15	USA	1075[4]	ARE	Fused salts	2·5	E	Advanced reactor experiment for aircraft. U235 in solution in fused fluorides
16	USA	604[28]	GEC	Na	546	D	Advanced sodium-graphite proposal
Organic Moderator							
17	USA	421[20]	OMRE	Organic	~10	E	For mobile or small power plant
	USA	—	Piqua	Organic	~50	D	Power demonstration, Piqua Pa.
Light-Water Moderator							
18	USA	465[1]	HTRE-1	Air	?	E	Advanced experiment. Very high outlet temperature
19	USA	2462[39]	PWR	H_2O	225	W	Shippingport. Zircalloy + UO_2 + U235 Zr alloy
	USA	2447[14]	Ind. Pt.	H_2O	585	B	
	USA	,,	Yankee	H_2O	480	B	St.steel cladding
	USA	1075[4]	APPR			W	St.steel clad, $U235\ O_2$ + S.S. powder
	USA	,,	Nautilus	H_2O	?	W	
	USSR	2184[40]	Volga	H_2O	760	B	Zr-Nb clad UO_2
20	USA	1075[4]	EBWR	Boil H_2O	60	W	Argonne. U-Zr-Nb alloy + Zr
		1923[41]	VBWR	Boil H_2O	30	W	Valecitos. S.S. clad
		2447[14]	Dresden	Boil H_2O	627	B	
		,,	Elk	Boil H_2O	~80	D	
		,,	N. States	Boil H_2O	164	D	
		,,	P. Gas	Boil H_2O	240	D	
	Belgium	1801[42]	GNEC	Boil H_2O	242	D	U.S./Belgian design study. Steam to heat exchanger
No Moderator							
21	UK	274[32]	Dounreay	Na	72	B	Reactor experiment
	USA	1782[33]	EBR-II	Na	60	B	Reactor experiment
	USA	2447[14]	E. Fermi	Na	450	B	Power plant
	USSR	2129[31]	BH50	Na	50	D	To be started after BH5 runs
	USSR	2129[31]	BH250	Na	250	D	Future system study
22	USA	—	EBR1	NaK	1·2	E	Reactor physics experiment
	USSR	2129[31]	BH5	NaK	5	B	RP experiment. PuO_2 fuel
23	USSR	2129[31]	—	He	—	P	He mentioned helium as possible fast-reactor coolant

Pu239) that re-fuelling is essential, and also (2) for re-cycling or burning plutonium, a fuel which will soon be becoming available in considerable quantities from the civil power reactor programme. For fuel elements, the trend is towards sintered uranium oxide.

Water Cooling

Although light-water cooling has been used with considerable success for cooling heavy-water reactors (for example, the NRX research reactor), design studies (see for example P209[17]) have shown that it is more economic for a power reactor to employ heavy-water cooling, notwithstanding the consequent large inventory of heavy water in the external circuit. Apart from the saving of neutron absorption, there are the obvious and important benefits that degradation of the moderator is much less likely since leaks in the coolant tubes would not be so directly liable to contaminate large volumes of moderator, although leaks from the heavy to light water in the primary heat exchangers must be carefully monitored, for example by the use of double tubes and tube-plates in the exchangers—a practicable proposition, however. Also there is a safety advantage since loss of light-water coolant (for example by boiling) must result in a considerable increase in reactivity.

There is then a choice to be made between pressure-vessel or pressure-tube construction. The Americans (P610[18]) and the Swiss (P246[19]) have studied both types, including the pressure-vessel variant in which the moderator is kept cool (below 100° C in most cases) while the hot coolant water is confined within thin-walled zirconium coolant tubes, heat insulated from the (cold) moderator heavy water. Little is said about the heat insulating materials for this application except that they must have a very low neutron absorption and must not be too thick to avoid neutron streaming. The choices seem to lie between a gas space, a heavy-water filled space or a magnesia (MgO) sintered tube or powder packing.

The insulation problem also arises in the same manner in the pressure-tube, cold-moderator variant, and, in addition, there is the choice of a low-neutron-absorption pressure tube. The Americans (P610[18]), Canadians (P209[17]), Swedes (P139[20]) and Swiss (P246[19]) all agree that zirconium or zircalloy is the best choice for the coolant tubes, whether thick or thin walled.

If the moderator is kept cool, then the 7 to 8 per cent of the total fission heat production which is generated in the moderator (due to neutron and gamma irradiation) is wasted at low temperature and cannot be added to the high-grade heat output. If the gains from the cool moderator (small critical size, long-term reactivity and plutonium economy, in combination or separately) are relinquished then the pressure-vessel, mixed coolant-moderator system may be used. In this case all the moderator heat goes into the main coolant and there need be no neutron-absorbing coolant tube, although cooling efficiency may dictate a guide-tube around each fuel stringer to constrain the main coolant flow to the region of the fuel elements. The economics of the various systems is finely balanced and can only be settled for a particular project by a careful design study.

Boiling-heavy-water cooling has not yet been developed as far as has light-water boiling, but this system has considerable potential and is being actively followed up in at least two countries. The boiling-heavy-water reactor now building in a rock cavern at Halden, in Norway (P559[21]), is intended to operate at about 40 atmospheres pressure, 250° C, producing some 10 MW of heat. This is essentially a very flexible reactor experiment to investigate the practical possibilities of this type of system, when used in large sizes, for burning natural uranium. In this small-sized reactor experiment it will actually be necessary to enrich the fuel once the moderator temperature is raised above 100° C. The first charge will be of natural uranium metal clad in an unbonded finned aluminium can; with this fuel charge the temperature will be limited to 150° C because of possible metal-water reaction, and if spiking is necessary this will be carried out using enriched uranium dioxide (UO_2) in stainless-steel cans. One of several experimental features in this reactor is the provision of shrouds around each fuel element to confine the upstreaming boiling mixture to the region of the fuel elements, keeping this flow separate from the down-flow between the elements; these shrouds may be removed if required for experimental purposes.

In the United States it is proposed to replace the present boiling light-water core of the EBWR at Argonne by a forced-circulation boiling-heavy-water core using urania-thoria fuel as a part of the experimental programme of this reactor. Although boiling heavy-water reactors appear attractive on grounds of reactivity, there are numerous unknown factors, such as uncertainties concerning regulation and practical problems of dealing with heavy water steam without undue losses.

Organic coolant has been seriously considered for heavy-water moderated reactors, particularly by the Canadians (P210[22]) and also by the Swiss (P259[23]) and the Americans (P606[24]) for application to smaller power plants (below 50 MW electric). Its main virtue is that the coolant system operates at a lower pressure while higher coolant outlet temperatures are available. Primary-circuit materials are also cheaper (constructional steel instead of the stainless steel is needed for pressurised water).

The liquid-fuel heavy-water moderated and

Continuing Power Reactor

cooled systems, namely the homogeneous reactor, has met a serious set-back in the shape of corrosion of the zirconium neutron window, but the HRE-2 at ORNL (P449[25]) is now operating as a single-region system. This scheme alone appears at present to offer substantial promise of positive breeding gain from a thermal reactor system, but it must be recognised that, in common with the liquid-metal systems, the highly radioactive primary circuit and the need for elaborate containment and servicing facilities put this reactor type into the "advanced" category that must require much development before it can become a serious competitor as a practical power reactor project.

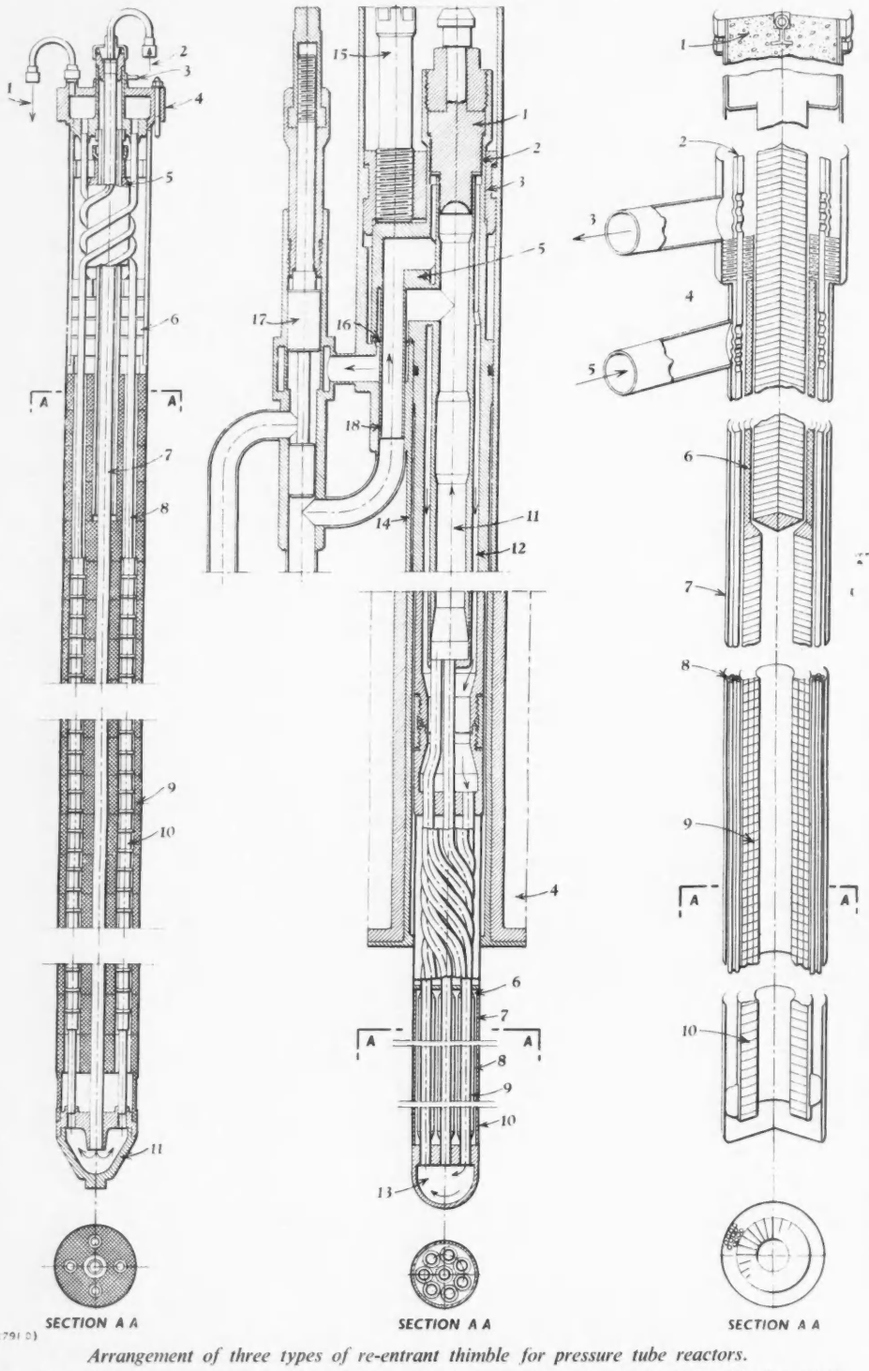
Gas Cooling

Considerable attention has been given to heat removal from heavy-water moderated reactors by gas cooling. One such plant, of Russian design and intended to produce 590 MW heat (150 MW electric) is now under construction in Czechoslovakia (P2092[2]) and design studies have been in progress in the United States (for example P2447[13]) and United Kingdom (P262[6]). The Russian design makes use of carbon-dioxide coolant with the pressure-vessel system, employing aluminium calandria tubes, thin unpressurised, unstressed coolant guide tubes and circulating gas (CO_2) insulation. Using magnesium-beryllium fuel cladding and uranium oxide fuel elements, a coolant temperature of 425° C is expected for a maximum can temperature of some 500° C. The United States and United Kingdom proposals favour the pressure-tube variant, since this permits the construction of very large reactor cores, giving as much as 500 MW (electric) per reactor.

A gas-cooled heavy-water system such as this gives many of the advantages of the gas-cooled graphite systems such as high outlet temperature, modest coolant pressure, absence of heavy-water leakage in the primary circuit, low radioactivity of coolant, freedom from corrosion problems and so on, and in addition avoids the graphite stored energy and gas-reaction (oxidation) problem. It also has no pressure vessel requiring inspection and maintenance. But at present heavy water makes for high capital cost.

Liquid Metal

Cooling, by liquid metals, using sodium, has been considered in the United States for heavy-water reactors and was considered for a 10 MW (electric) power plant at Anchorage, Alaska, but was not mentioned in Dr. Norman Hillbery's review of United States power-reactor projects (P2447[14]). Although providing potentially high coolant outlet temperatures for low primary circuit pressures it is evident that a scheme of this sort has serious compatability and safety considerations. In its original form (as previously described in ENGINEERING[26]) it relied on stainless-steel coolant tubes and fuel cans and this, together with the neutron absorption by the sodium, resulted in a need to enrich the fuel 1·5 to 2 per cent or more. Any development of this type would seem to depend upon the use of zirconium with sodium, as in SGR.



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Arrangement of three types of re-entrant thimble for pressure tube reactors.

One of the 128 re-entrant pressure-tube thimbles for pressurised (100 atm.) light-water cooled graphite-moderated reactor. (First Soviet atomic power station later adapted for boiling conditions.[11]) 1 Water outflow from channel, 2 Water inflow into channel, 3 Gas removal from channel cell, 4 Upper head of fuel channel, 5 Aluminium bush, 6 Protection bush, 7 Central tube 15 by 0·6 mm, 8 Peripheral tube 9 by 0·4 mm, 9 Graphite bush, 10 Fuel element, 11 Tail end of fuel channel.

One of 88 re-entrant pressure-tube thimbles for pressurised (60 atm.) heavy-water-cooled heavy-water moderated reactor (Sulzer-designed Swiss power reactor[10]). 1 Plug, 2 Sealing membrane, 3 Closure unit, 4 Upper reactor shield, 5 Fuel element headpiece, 6 Graphite powder filling, 7 Insulation tube, 8 Uranium tube, 9 Zirconium pressure tube, 10 Outer casing tube, 11 Coolant return duct, 12 Coolant supply, 13 Coolant header, 14 Tube mounting for fuel element, 15 Main tightening spindle, 16 Main seal, 17 Double slide valve, 18 Coolant connecting pipe.

One of 37 re-entrant low-pressure (~3 atm.) thimble tubes for sodium-cooled graphite-beryllium-moderated reactor proposal (United States advanced thermal sodium-cooled power reactor[38]). 1 Top plug, 2 Fuel hanger, 3 Sodium out, 4 Seal, 5 Sodium in, 6 Shield, 7 Module wall, 8 Fuel rods, 9 Beryllium, 10 Reflector.

Beryllium and Beryllia Moderators

Beryllium and its oxide, beryllia, have not yet become important as moderators except for some rather specialised applications such as the reflector for the MTR research reactor and the very interesting ARE experiment referred to earlier. High cost and difficulty of fabrication probably mainly account for this. The application of beryllia as a moderator is clearly to very high temperature systems, being chemically stable in the presence of high-temperature coolants including gas and liquid sodium: the latter was used for cooling the ARE moderator.

It has been considered as an alternative to graphite for the British HTGC reactor (P314[27]) on account both of its chemical stability towards gaseous coolants and its excellent moderating properties which would lead to high conversion ratios. Beryllium metal has been considered by the United States (P604[28]) for a sodium cooled, uranium dioxide (UO_2) fuelled central power station system in which the moderation is partially by graphite, partially by beryllium metal (5·4 : 1:: graphite : Be by volume). This reactor is comparable with the SGR, but having no zirconium is able to attain outlet temperatures of over 520° C, while achieving a conversion ratio of 0·69 on the Th232-U233 cycle.

Organic Moderators

The only organic moderated power reactor scheme at the present time is the Organic Moderated Reactor Experiment (OMRE: see P421[29]). The reason for using this hydrogenous material as a moderator is that it has similar moderating properties to those of water but can be operated at high temperatures (~ 400° C) at about a tenth of the pressures required for a pressurised-water system. The

obvious coolant is the organic liquid itself, which permits quite good steam conditions to be attained: but it is conceivable that other coolants might be used for special applications.

The polyphenyls show quite good radiation-plus-temperature resistance (as reported in ENGINEERING[30]), and this coupled with its excellent non-corrosive properties, including a very slow reaction rate with uranium metal at high temperatures, and its low radioactivation by neutrons, make it a promising material for small stationary or mobile enriched-fuel power plants of low capital cost.

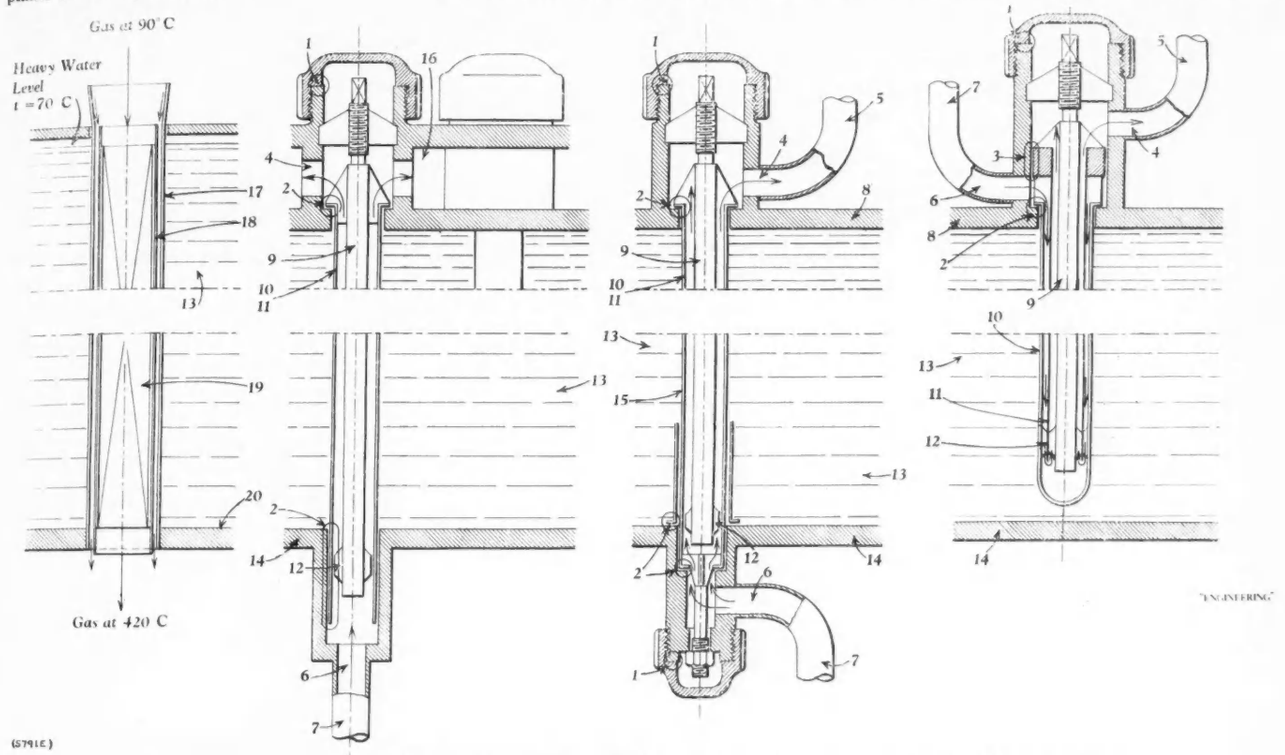
power programme; and both USA and USSR are interested in these reactors for mobile applications.

Coolant and moderator are either indistinguishable or at any rate, even if coolant flow guide tubes are used, in direct physical contact, and the whole reactor core must therefore be pressurised. If boiling is to be suppressed, this entails pressures of 100 to 150 atmospheres: but experience is now proving that the complete suppression of boiling within the core is not essential to reactor stability and in fact the Yankee pressurised-water-cooled reactor[14] is

sq. in, 530° F or 70 atmospheres, 285° C) cannot match those which can be attained in gas-cooled systems, which would appear, therefore, to have more development potential.

The trend in fuel elements for water-moderated water-cooled reactors is again towards ceramics, either of uranium oxide (UO_2) or thorium oxide or mixed, these materials giving excellent long-term irradiation stability, chemical inertness to the water coolant in the event of can rupture, and very high acceptable fuel-central temperatures.

Zirconium alloy is the preferred cladding for water-cooled reactors on the ground of its



Three possible arrangements of straight-through pressure tubes, together with a re-entrant tube (right) for comparison.

Key: Swiss—1 Seal between coolant and moderator space, 2 Seal between coolant and surroundings, 3 Seal between coolant inlet and outlet, 4 Coolant outlet, 5 Collector pipe, 6 Coolant inlet, 7 Distributor pipe, 8 Upper end plate, 9 Fuel element, 10 Pressure tube, 11 Coolant flow tube, 12 Guiding fins, 13 Moderator, 14 Lower end plate, 15 Moderator canning tube, 16 Coolant header; Soviet (left)—17 Calandria tube, 18 Baffle tube, 19 Fuel element assembly, 20 Bottom of container.

Light Water Moderation

Light water is a " good " moderator in the sense that the hydrogen in the water quickly slows down the fission-energy neutrons and contributes a small characteristic length for neutron migration, but is " poor " by comparison with the other practicable moderators on account of its rather large neutron absorbing properties. This means in practice that it is necessary to use enriched fuel in a water-moderated system to make it critical, but this extra initial capital investment in fuel is offset to a considerable extent by the cheapness of the moderator. In addition, the compactness of the resulting reactor, on account of the short characteristic lengths, results in turn in a higher attainable power density for the core and thus, by and large, in an economy in capital investment in plant hardware. There is no incentive to try to keep the moderator cool, since it is essential in any case to enrich the fuel to obtain criticality, and the core is already compact enough to meet pressure-vessel requirements.

Water Cooling

The simplest and most obvious coolant for use with light-water moderation is the light water itself, which may either be so highly pressurised as to prevent boiling or may be allowed to boil in the reactor core. These two schemes represent the main systems now being developed in the United States, and pressurised-water reactors also form an important fraction of the USSR's

being designed to operate with nucleate boiling within the core, which is the condition for maximum surface heat flux. At one time it appeared that the attainable power densities with pressurised-water reactors would always exceed those of the boiling type, but in fact the 75 kW per litre of the Shippingport reactor is being rivalled by the EBWR, which has attained 65 kW per litre at 600 lb per sq. in, and the Vallecitos BWR has also achieved over 50 kW per litre, with an expectation of achieving 100 kW per litre. The Dresden BWR is designed for 53 kW per litre. If the core rating of the boiling reactors can be made to rival those of the pressurised-water reactors then the remaining advantages seem to be with the boiling type, because (*a*) the core pressure may be chosen to be higher than is attainable in the secondary circuit of a PWR for a given core outlet temperature, which enables the advantages of superheating to be exploited; (*b*) the core and steam circuit pressures are much lower (40 to 70 atmospheres) than in the PWR type (100 to 150 atmospheres) with corresponding savings in capital cost; (*c*) in the direct-cycle type no primary heat exchanger equipment is required; and (*d*) pumping power is lower, especially in the natural air circulation type.

However, unless superheating can be employed, either by the use of fossil fuel (as in the Indian Point PWR and the Belgian BWR), or by some special reactor superheater application as developed in the Russian graphite reactors, the steam conditions produced (up to 1,000 lb per

low neutron absorption, but it still appears to be suspect because of the possibility of water-metal reactions, and hence for applications where a firm guarantee of safety is required, especially if the highest temperatures are to be used, stainless steel is being specified for fuel cans. Examples of water-cooled plants using stainless-steel fuel cladding are the APPR, the Yankee power plant, the Vallecitos BWR and the Dresden boiling-water power station, and the Belgian boiling-water reactor.

In the Soviet Union, zirconium-niobium alloys are being used. For highly-enriched fuel elements, where some dilution of the fuel material is essential to limit to an acceptable magnitude the heat generation within fuel elements of practicable (that is, robust) dimensions, several approaches are being explored. One is the use of U-Al or Pu-Al alloy, the former as in the DIDO or MTR class research reactors, the latter as successfully tried recently in the MTR reactor at Idaho. In the stainless-steel clad APPR elements, UO_2 dispersed in stainless steel is employed; in the Shippingport reactor, uranium 235-zirconium alloy, clad in Zircalloy 2, is used; and in the EBWR, a U-Zr-Nb alloy is adopted, again clad in Zircalloy 2.

Experience (PI075[4]) with both the forced convection and boiling types of light-water moderated reactors has shown them to be reliable and satisfactorily stable power plants, both having excellent self-regulating characteristics. In the case of the boiling-water type, in which the reactor-produced steam is fed directly

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to the turbine, it is reported that radioactivity carried from the reactor into the turbine is a "minor and entirely manageable problem," although insufficient experience of the effects of fuel-element rupture has yet been obtained.

Other Coolants

Apart from the one air-cooled high-temperature experiment (P465[1]) in which very high coolant temperatures were obtained with a light-water moderated reactor, there do not appear to be any proposals to use alternative coolants with light water.

No Moderator: Fast Reactors

Despite the fact that since the fast-reactor schemes were first launched very large reserves of uranium have been discovered, so making less urgent the need to conserve uranium 235 resources, it remains the case that the only really good prospect of burning uranium 238 (by conversion to plutonium 239) is the fast-neutron breeder reactor, which can produce more new plutonium atoms than it burns of uranium 235 (or plutonium 239) atoms.

There are three outstanding characteristics of the fast reactor: its very small core size (a few hundred litres), its very large critical investment of fissile material (a few hundred kilogrammes) and its dependence upon a non-moderating, highly efficient coolant: so far, sodium is the only material seriously considered, although helium gas cooling has apparently been considered by the Russians (P2129[31]). To make such a system economic it is essential to extract not too much less than 1 MW per kg from the fissile material investment. This requirement leads to very high power densities in the core of up to and over 1 MW per litre, and fuel metal ratings of as much as $\frac{1}{3}$ MW per kg.

This presents a considerable engineering problem, but if it can be satisfactorily solved, as seems likely given development time, then this type of reactor offers the possibility not only of burning uranium 238 and plutonium but also of being a low capital cost system on account of its small bulk of hardware. Given favourable fuel costs and associated reprocessing charges, therefore, this type of reactor may contribute to the peak-load problem, since the economics of large (base-load) thermal reactors hinge upon high load factors.

The United Kingdom (P274[32]), United States (P1782[33]), and USSR (P2129[31]) are the only countries developing this system at the present time, and the status of the projects in the three countries is roughly similar. All three have carried out extensive zero-energy and low-power reactor physics investigations, demonstrating among other things the breeding potentialities of the system, all three are now building small or intermediate sized reactor experiments of substantial thermal output capacity (Dounreay 72 MW, EBR-II 62·5 MW, BH5 5 MW), and all three are considering or building full-scale power-reactor projects. Of these latter, only the 300 MW (heat) United States Enrico Fermi reactor is actually under construction, near Detroit. It is due to go critical in September, 1961.

British and American fast-reactor fuel technology is based upon uranium metal alloys, clad in niobium and vanadium in the United Kingdom, stainless steel in the United States, with molten-sodium thermal bonding between fuel and can. In the USSR also metal alloys (for example U + Pu + Fe, Ba, etc.) are foreseen as the fuel type required for high heat extraction rates, but it is of interest to note that in the BH5 (5 MW) experimental fast reactor now building, use is made of sintered plutonium oxide fuel elements in stainless-steel cans with NaK (sodium-potassium alloy) coolant. NaK is a useful coolant for an experimental machine of relatively low power since it is molten at room temperature and therefore requires no trace heating to keep it molten in the circuit, but for any large power plant installation sodium is preferred on economic grounds, and since the fuel in a power reactor produces quantities of radioactive decay heat at all times after initial start-up, it is only the first charging that creates a pre-heating problem.

Conclusions

The power-reactor business has grown into a large industry coupled with a broad technology and it would be impossible to do it justice in one relatively short article: it will be recalled that some 2,500 papers were presented to the Geneva Conference; significant meetings on nuclear power matters occur with increasing frequency all over the world; while every day increasing numbers of papers, periodicals, journals and text-books appear containing many fresh analyses and ideas. Nevertheless, the main pattern of the technology of obtaining heat or electric power from the fission process has remained substantially the same now for some years, and what has been said above is an attempt to map out its main outlines and highlights without entering into too much detail.

Many important topics have had to be ignored altogether or merely touched on: examples are problems of control and stability, long-term reactivity and the end-product of them all, the economics. The fact is that the obviously poor starters have now dropped out of the running, and the schemes now receiving detailed theoretical, experimental and full-scale attention all have their merits and weaknesses and only a fine study of detailed considerations, and optimisation of the various parameters, technical, economic, temporal and even political, to suit a particular application, can now demonstrate which system is best suited to a given duty, location and decade.

To try to summarise the present situation and outlook in one paragraph, one might say this: the water-water reactors offer immediate plants of a variety of sizes, from portable and propulsion units to full-scale power plants, of fairly low capital cost, rather poor steam conditions, depending upon a supply of enriched fuel, but with a well-tested (though advanced and specialised) technology to back them. The gas-cooled systems, either graphite or heavy-water moderated, offer better economics, especially in large sizes and in low capital cost regions, since they can use natural or near-natural uranium and have good conversion ratios especially in the case of the heavy water types; and in addition the gas-cooled types have an excellent development potential for high-temperature working and use perhaps more conventional engineering technologies. The light-water cooled graphite-moderated systems appear to possess the disadvantages of both graphite-gas and water-water types without being able to exploit the advantages of either, that is, high temperatures and fuel economy in the one, simplicity in the other; however, steam cooling (superheating) does look useful if it can be reconciled with neutron economy. The heavy-water-water types do have much of the simplicity of the light-water-water types with the added prospect of good fuel economics, but without high-temperature development potential to give improved heat conversion efficiencies unless steam cooling is used. The remaining thermal types seem to be specialised in application (for example, propulsion or remote areas) or to depend upon advanced technologies still some way off as developed propositions, sharing many of these difficulties with the fast fission reactor but without the great incentive of the fast-reactor type of positive breeding gain and potentially excellent economics.

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Research and Development

AERODYNAMICS OF WAKES

Existence of Unsteady Cavities *

By A. J. Taylor Russell
B.SC.(ENG.), A.C.G.I., D.I.C.†

A STREAMLINED two-dimensional obstacle placed in a steady flow of a " real " fluid generates a steady wake from the boundary layers which grow on each side, providing the curvature of the sides is not so great as to produce separation of the boundary layers from the surface.

When a body is not streamlined but is bluff as, for example, in the case of a circular cylinder or a flat plate with its face at right-angles to the direction of flow, separation of the boundary layers occurs and the wake ceases to be steady. Instead, for a certain range of values of the non-dimensional flow parameter, the Reynolds number, regular fluctuations of large amplitude are found in the values of the velocity and pressure measured at any fixed point in the wake. Beyond this range of Reynolds number the wake is still very unsteady but regular oscillations are not always found. If an experiment is carried out in an open water channel, so that the free surface of the water cuts through a section of the obstacle, then the flow in this unsteady wake can be studied by sprinkling some light particles on to the water surface. Such an experiment suggests that the fluctuations result from a regular series of eddies which spring alternately first from one side of the obstacle and then from the other, so that far downstream the wake consists of an evenly spaced double row of eddies, each row containing eddies of the same sign and opposite to that of the eddies in the other row, with each eddy in one row positioned longitudinally mid-way between an adjacent pair in the other row. The two rows of eddies, known collectively as a vortex street, drift down-stream at a speed just less than that of the free stream and the frequency of the fluctuations which are picked up at a fixed point in the wake is, for a given obstacle, nearly proportional to the speed of the free stream. For a given speed and shape of obstacle it is also found that the frequency is inversely proportional to the width of the obstacle.

The first to notice the dependance of the frequency upon the speed and the width of the obstacle was V. Strouhal and he defined a non-dimensional frequency, the Strouhal number, as $S = \frac{n\,b}{U}$, where n is the frequency, b is the width of the obstacle and U is the free stream speed. Using consistent units experiment gives an average figure of about 0·2 for S. Around this average figure there is some variation, notably between the figures for differently shaped obstacles. Thus the figure for the circular cylinder is greater than that for the flat plate, largely because the flat plate generates a broader wake than a cylinder of the same diameter.

Explanations of the periodic wake are usually based on such visual experiments as the one just described and on the suggestion of von Karman that each eddy be represented as a point concentration of vorticity instead of a substantial core of vorticity. By consideration of the first order stability of this ideal vortex street, far downstream, von Karman showed that there could be only one stable ratio of the lateral to longitudinal spacing of the vortices, namely 0·281. Occasionally a figure close to this has been measured experimentally, but generally the ratio is greater than this and figures as high as 0·5 have been measured. The vortex street explanation supposes that the vortex sheets, which are shed from each side of the obstacle with the separation of the boundary layers, roll up alternately to produce centres of vorticity which may fairly be regarded as point concentrations; but Birkhoff[1] has shown by energy considerations, that, even in inviscid flow, the vortex sheets cannot roll up into circles whose diameter is less than about one-quarter of the longitudinal spacing of one row, or about one half of the distance between two adjacent vortices of opposite signs. In a viscous fluid the minimum diameter is likely to be even larger because of the effects of viscous dissipation.

Thus it is clear that the concept of an ideal vortex street consisting of point concentrations of vorticity, drifting downstream from the obstacle in otherwise inviscid fluid, is not a good representation of the wake of a bluff body in a real, viscous fluid.

Fig. 1 Circular cylinder with tail plate.

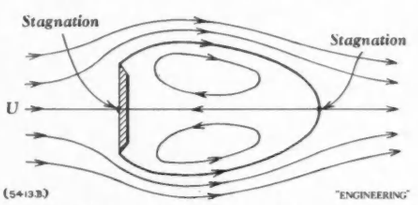

Fig. 2 Mean streamlines observed in the wake of a flat plate.

The vortex street analysis depends upon the persistence of a stable double row of vortices far downstream but some experiments made in the vicinity of the obstacle show that the occurrence of a periodic wake is determined by what happens during the first few diameters of the wake. For example, the regular oscillations can be prevented completely by the introduction of a short tail plate which divides the wake into two for the first five diameters. The arrangement of this tail plate is shown in Fig. 1. If a shorter plate is substituted then the amplitude of the oscillations is reduced and the frequency is altered. So the early stages of the wake rather than the flow downstream may be expected to provide an explanation of the periodic wake.

If streamlines are constructed from the mean values of the velocities measured in the wake, then a short cavity, that is a region containing closed streamlines, about 4 or 5 diameters in length, is found just downstream of and attached to the obstacle. Fig. 2 shows streamlines so constructed for the wake of a flat plate normal to a stream of air. The heavy line is the streamline which marks the boundary of the cavity. It will be seen that at the downstream end of the cavity there is a free stagnation point where the two halves of the bounding streamline join up.

The pattern of mean flow streamlines shown in Fig. 2 does not necessarily represent the mean of the streamline patterns in the unsteady flow since any lateral velocity fluctuations, corresponding to lateral movements of the streamlines, may be of the same order of magnitude as the measured mean velocity and may therefore result in large errors in the measurement of velocity and the estimation of streamline position. The estimation of streamline position is in any case very approximate since, particularly in unsteady flow, it is usual for the velocity but not the streamline direction to be known at each point. So it might be that the closed cavity found in the mean flow streamlines is not the mean position of an oscillating cavity at all but solely a result of using mean velocities in very unsteady flow. The question of whether the wake contains an unsteady cavity, possibly one which oscillates from side to side, was considered too important to leave only partly answered, so some further experiments were designed to test the idea.

A series of smoke filaments were injected into a stream of air passing a flat plate and illuminated with a stroboscopic light as they passed the plate. The frequency of the stroboscope was then adjusted until it was equal to the frequency of the wake oscillations, this being achieved by searching for a stationary pattern near the frequency which had been reckoned from measurements of the Strouhal number. It was hoped that it would be possible to photograph the stationary flow pattern corresponding to one or other extreme position of the streamlines but the illumination was too poor; instead, sketches were made of the rough location of the filaments. From these sketches the streamline pattern shown in Fig. 3 was constructed. This figure shows the streamlines at the instant when the deviation of the flow from the mean position is greatest and it is clear that the cavity exists in the unsteady flow as well as in the mean flow. Moreover, the free stagnation point forms well to one side of the centre line in this asymmetrical cavity. Thus, in order to produce an average stream-

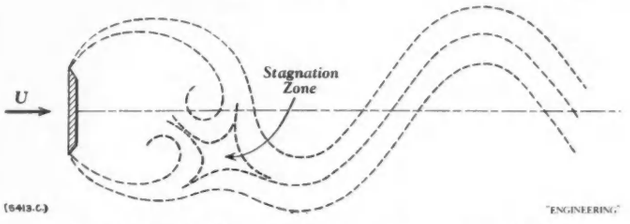

Fig. 3 Smoke filaments in an unsteady flow past a flat plate.

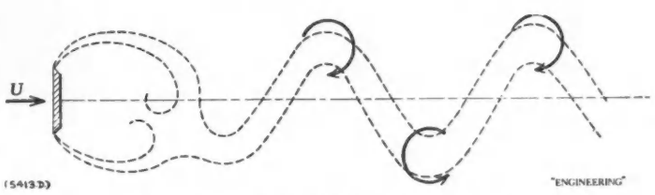

Fig. 4 Concentrations of vorticity in the wake.

* Paper read before Section G, British Association, at Glasgow on Monday, 1 September 1958.

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Continuing **Research and Development**

line pattern which is symmetrical about the centre line of the plate, the cavity must oscillate between the shape shown in the figure and the reflection of this in the centre line; and the stagnation point must oscillate with it. A study of the events farther downstream shows that these lateral oscillations of the stagnation point result in a sinuous wake which trails downstream from the cavity and it will be useful to examine the formation of this wake in some detail.

In the configuration drawn in Fig. 3 the circulation around the plate and cavity, taken as a whole, will not be zero because of the asymmetry of the flow. A quarter of a cycle later, that is in the symmetrical configuration, the circulation will be zero and after a further quarter of a cycle the circulation will be equal and opposite to that in Fig. 3. As a result of these cyclic changes in the circulation around the plate and cavity, similar cyclic changes should be apparent in the sinuous wake and further examination of the process shows that these should be such as to give concentrations of vorticity at each " peak " or " trough " in the wave-like shape of the wake. Fig. 4 is a modification of the previous figure showing the distribution of vorticity in the wake, with the sign of each concentration indicated with an appropriate arrow.

The main difference, apart from the formation of the cavity, between this new explanation and that of the vortex street lies in the variation of vorticity in the wake, here regarded as continuous. However this continuous distribution of vorticity is sufficiently similar to the discrete centres of the vortex street for the visual evidence of the water surface patterns to be satisfied by both explanations. The explanation of the water surface pattern reproduced by, for example, Goldstein,[2] using the vortex street idea, is fairly clear since the pattern consists of a regular series of whirls. Representing the wake, in this new explanation, as a wavy vortex street, with a sinusoidal distribution of vorticity, particle velocities at right angles to the sheet will be induced wherever the sheet crosses the centre line of the plate, so that the swirling flow pattern reproduced by Goldstein would soon appear. Probably these same induced velocities would also distort the form of the wake after a few diameters.

The last point concerning these experiments is that they offer a partial explanation of the cancellation of the wake oscillations by the introduction of a tail plate, as described earlier. The connection between the wake oscillations and the oscillations of the stagnation point has been established, so that when stagnation occurs on the solid surface of the tail plate and freedom to oscillate laterally is removed, the wake oscillations disappear, although the cavity remains. The explanation is only a partial one since of course it merely removes the query to the reason for the instability of the stagnation point. The problem of the instability of free stagnation points must therefore be tackled before the periodic wake can be fully understood.

SIMILARITIES TO OSCILLATING AEROFOILS

An aerofoil at incidence to a stream of air generates lift because the front stagnation point is free to form anywhere on the rounded nose whereas the rear stagnation point can only form at the trailing edge, which has been made sharp for this purpose. In this way the asymmetry necessary to produce circulation around the aerofoil can be forced upon the flow. If the aerofoil has a symmetrical section and is pivoted about its leading edge then oscillations of the aerofoil in pitch will result in cyclic changes in the circulation around the aerofoil, similar to the changes in the circulation around the cavity in the periodic wake which were described earlier. As a result of this similarity the wake of an oscillating aerofoil should show a visual likeness to the periodic wake of a bluff obstacle. That such a visual likeness is observed[3] offers much support to the author's explanation of the periodic wake.

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OPEN CIRCUIT TELEVISION *for* TRACK TESTS

To help in studying the behaviour of cars and trucks in motion, Vauxhall Motors' engineers are now using open circuit television at the Vauxhall Test Centre at Chaul End, near the company's Luton and Dunstable factories. The transmitting licence is claimed to be the first to be issued by the General Post Office for industrial use in Great Britain.

The camera, mounted on the vehicle close to the component being observed, is connected to a small transmitter inside the body or cab. The aerial is fixed to the roof of the vehicle, and transmits to a receiver aerial on the roof of the nearby research laboratory. This is connected to a normal television receiver inside the building where several people are able to study the picture at one time.

The technique, still being perfected by Vauxhall's research men, is being used in a number of ways. Already it has successfully revealed the cause of intermittent localised vibration on some models at certain critical speeds. The engineers expect to get particularly useful results by studying the behaviour in action of springs and shock absorbers, propeller shafts and many other hard-to-see components.

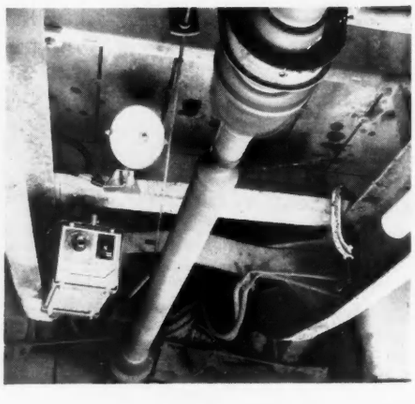
Vauxhall have used closed circuit television at Chaul End for the past two years. Before that a ciné camera was the only way of providing pictorial information. This is fixed in an appropriate spot on the vehicle to film the components being studied; but the system involves delays for developing the film, and the possibility of having to re-take if the results were not satisfactory.

The closed circuit television link marked a big step forward. Because initially the viewing screen had to be carried in the car or truck being observed, it was impossible at first for more than two people to study the results at one time. Hence the decision to develop a system with the receiver stationary in the laboratory.

No suitable transmitter was found to suit the specialised needs of this work, so Vauxhall built one themselves. Because the frequency allotted by the GPO (750 Mc/s) is not normally used for television in this country, they had little information or experience to draw on, and progress was at first rather slow.

At present, the whole unit fits into a case 16 in by 14 in by 6 in, which matches the size of the camera remote control gear. There is still some picture flutter when the transmitting vehicle is moving fast, but this does not preclude accurate observation, and will probably be overcome within the next few months. Power for the transmitter and for the lamp that illuminates the subject is provided by a petrol-engine driven generator or rotary converter carried in the boot of the car.

A test Victor on the banked turn of the 1¼ mile perimeter track of Vauxhall's test centre. In the background is the laboratory building with its television receiving aerial.



Showing how the television camera and spot-light are mounted beneath a Bedford truck.

EXHIBITIONS AND CONFERENCES

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk (*). For details of events not included below, reference should be made to ENGINEERING, *26 September, page 422, and 31 October, page 564. Organisers are invited to send particulars of coming events to the Editor.*

National Power Show (Exposition of Power and Mechanical Engineering).—Mon., 1 Dec., to Fri., 5 Dec., in the New York Coliseum, New York. Organised by the International Exposition Co., 480 Lexington Avenue, New York 17.

***British Products Exhibition.**—Tues., 2 Dec., to Fri., 5 Dec., in the Sports Palace, Havana, Cuba. Apply direct to the British Embassy, Apartado 1069, Havana, Cuba; or to the Commercial Relations and Exports Department, Board of Trade, Horse Guards Avenue, London, S.W.1. Tel. TRAfalgar 8855, ext. 2018.

British Institute of Radiology, Annual Congress and Exhibition.—Thurs. and Fri., 4 and 5 Dec., at Church House, Great Smith Street, London, S.W.1. Organised by the Institute, 32 Welbeck Street, London, W.1. Tel. WELbeck 6237.

Smithfield Show and Agricultural Machinery Exhibition.—Mon., 8 Dec., to Fri., 12 Dec., at Earl's Court, London, S.W.5. Apply to the exhibition manager, Smithfield Show Joint Committee, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

Electronic Digital Computers and Their Industrial Applications, Conference.—Wed., 10 Dec., in the Department of Mathematics College of Technology, Birmingham. Fee £2. Apply to the registrar, College of Technology, Gosta Green, Birmingham 4. Tel. Aston Cross 3611.

POWDER METALLURGY

***Powder Metallurgy of Ceramic-Metal Materials, Symposium.**—Tues. and Wed., 16 and 17 Dec., at Church House, Great Smith Street, London, S.W.1. Organised by the Powder Metallurgy Joint Group of the Iron and Steel Institute and the Institute of Metals. Apply to the Institute of Metals, 17 Belgrave Square, London, S.W.1. Tel. BELgravia 3291.

American Association for the Advancement of Science.—Fri., 26 Dec., to Wed., 31 Dec., at Washington, D.C., USA. Offices of the Society: 1515 Massachusetts Avenue N.W., Washington 25, D.C., USA.

Boat Show, Fifth National.—Wed., 31 Dec., to Sat., 10 Jan., 1959, at Olympia, London, W.14. Organised by the Ship and Boat Builders' National Federation, 205 Regent Street, London, W.1. Tel. REGent 1108.

National Motor Boat Show.—In January, 1959, at the New York Coliseum, New York. Organised by the National Association of Engine and Boat Manufacturers, Inc., 420 Lexington Avenue, New York 17, USA.

International Toy Fair.—Sat., 10 Jan., to Fri., 16 Jan., 1959, at Harrogate. Apply to the Harrogate International Toy Fair Ltd., Finsbury Court, Finsbury Pavement, London, E.C.2. Tel. MONarch 8921.

Housewares Exhibition, National.—Thurs., 15 Jan., to Thurs., 22 Jan., 1959, in Chicago. Organised by the National Housewares Manufacturers' Association, 1140 Merchandise Mart, Chicago 54, Ill., USA.

Physical Society's Exhibition of Scientific Instruments and Apparatus, 43rd.—Mon., 19 Jan., to Thurs., 22 Jan., 1959, in the Royal Horticultural Society's Old and New Halls, Vincent Square and Greycoat Street, London, S.W.1. Organised by the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7. Tel. KENsington 0048.

***Detroit News Boat Show.**—Sat., 24 Jan., to Sun., 1 Feb., 1959, in Detroit. Offices: 16738 E. Warren Avenue, Detroit 24, USA.

Physical Society of America, Annual Exhibition and Convention.—Wed., 28 Jan., to Sat., 31 Jan., 1959, at the Hotel New Yorker, New York. Organised by the American Institute of Physics, 33 East 45th Street, New York 17, USA.

FACTORY MANAGEMENT

Factory Management Conference and Exhibition, 11th.—Wed., 28 Jan., to Wed., 4 Feb., 1959, at Netherland Hilton Hotel, Cincinnati. Information from Mr. G. B. Albritton, 342 Madison Avenue, New York 17, USA.

Long-Distance Transmission by Waveguide, Convention.—Thurs. and Fri., 29 and 30 Jan., 1959, at the Institution's headquarters in London. Organised by the Radio and Telecommunication Section. Apply to the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. Tel. TEMple Bar 7676.

***Hobby Industry Show.**—Sat., 31 Jan., to Wed., 4 Feb., 1959, in Chicago. Organised by Mr. William L. MacMillan, 1528 Walnut Street, Philadelphia 2, Pa., USA.

***Brazilian Trade and Industry International Exhibition.**—From Sat., 31 Jan., 1959, at Rio de Janeiro. To be held in two sections: that for Brazilian industry will open on 31 Jan.; opening date for the international section will probably be in March, 1959; closing dates for the two sections not yet settled. Organisers: Ministerio do Trabalho, Industria e Comercio, Palacio Trabalho, Avenida Presidente A Carlos 251, Rio de Janeiro D.F., Brazil.

Materials Handling in Canadian Industry Exposition.—Mon., 2 Feb., to Fri., 6 Feb., 1959, at the Automotive Building, Toronto. Organised by *Materials Handling in Canadian Industry*, 2 Bloor Street East, Toronto 5, Canada.

***Hotel and Restaurant Suppliers Exhibition.**—Tues., 3 Feb. to Fri., 6 Feb., 1959, in the Show Mart Building, Montreal. Organised by the Hotel and Restaurant Suppliers Association Inc., 1638 Sherbrooke Street West, Montreal PQ, Canada.

New Building Materials and Techniques, Exhibition.—Fri. and Sat., 6 and 7 Feb., 1959, at the Royal York Hotel, Toronto. Organised by the Ontario Association of Architects, 50 Park Road, Toronto, Ont., Canada.

National Boat Show.—Fri., 6 Feb., to Sun., 15 Feb., 1959, in the International Amphitheatre, Chicago. Organised by the Outboard Boating Club of America, 307 North Michigan Avenue, Chicago, USA.

Canadian Hardware Show, 54th Annual.—Mon., 9 Feb., to Thurs., 12 Feb., 1959, in the Canadian National Exhibition Grounds, Toronto. Organised by the Canadian Retail Hardware Association, 290 Merton Street, Toronto 7, Ontario, Canada.

Stationery Trade Fair, Fifth.—Mon., 9 Feb., to Fri., 13 Feb., 1959, at Alexandra Palace, London. Organised by the Stationers' Association of Great Britain and Ireland, 6 Wimpole Street, London, W.1. Tel. LANgham 9256.

Power Farming Conference, National.—Tues., 10 Feb., to Thurs., 12 Feb., 1959, at Harrogate. Theme: "Machinery and Men." Organised by *Practical Power Farmer* and the *Farmer and Stock Breeder*, Dorset House, Stamford Street, London, S.E.1. Tel. WATerloo 3333.

British Hosiery and Knitwear Exhibition.—Mon., 16 Feb., to Fri., 20 Feb., 1959, at Seymour Hall, London. Organised by Industrial Exhibitions Ltd., 9 Argyll Street, London, W.1. Tel. GERrard 1622.

Toy Fair.—Mon., 16 Feb., to Fri., 20 Feb., 1959, at Brighton. Organised by the British Toy Manufacturers Association, 93-94 Hatton Garden, London, E.C.1. Tel. CHAncery 9158.

Stationery and Book Trades Fair, National.—Mon., 16 Feb., to Fri., 20 Feb., 1959, at the Royal Horticultural Society's Old and New Halls, Vincent Square and Greycoat Street, London, S.W.1. Organised by the *National Newsagent, Bookseller and Stationer*, 149 Fleet Street, London, E.C.4. Tel. CITy 2604.

Scottish Dairy Show.—Tues., 17 Feb., to Fri., 20 Feb., 1959, at the Kelvin Hall, Glasgow. Organised by the Glasgow Agricultural Society, 51 Moss Street, Paisley. Tel. Paisley 6244.

ALBERTA MOTOR SHOW

Alberta Motor Show.—Tues., 17 Feb., to Sun., 22 Feb., 1959, at the Jubilee Auditorium, Edmonton, Alberta. Organised by the Alberta Motor Show Committee, c/o Edmonton Symphony Society, Hudson's Bay Store, Jasper Avenue, Edmonton, Alberta, Canada.

***Automotive Service Industries Show, International.**—Wed., 18 Feb., to Sat., 21 Feb., 1959, at the Navy Pier, Chicago. Organisers: A. B. Coffman Associates, 28 East Jackson Boulevard, Chicago 4, Ill., USA.

***Practical Householder Exhibition.**—Wed., 18 Feb., to Sat., 28 Feb., 1959, at Earl's Court, London, S.W.5. Organised by Trade Fairs and Promotions, Ltd., Drury House, Russell Street, London, W.C.2. Tel. TEMple Bar 3422.

***American Concrete Institute, Annual Convention.**—Mon., 23 Feb., to Thurs., 26 Feb., 1959, at the Statler Hilton Hotel, Los Angeles, Calif., USA. Institute offices: P.O. Box 4754, Redford Station, Detroit 19, Mich., USA.

Melbourne International Trade Fair.—Thurs., 26 Feb., to Sat., 14 Mar., 1959, at the Exhibition Buildings, Melbourne. Organised by the Melbourne Chamber of Commerce, 422 Collins Street, Melbourne.

***Israel Agricultural Exhibition.**—In March, 1959, at the Beth Dagan Fair Grounds, Tel Aviv. Organised by the Israel Agricultural and Development Exhibitions Co., Ltd., 2 Carlebach Street, Tel Aviv, Israel.

Utrecht International Spring Fair.—*Consumer Goods:* Mon., 9 Mar., to Sat., 14 Mar., 1959, at Utrecht, Holland. *Technical Fair:* Wed., 15 April, to Fri., 24 April, 1959, at Utrecht, Holland. Apply to Mr. W. Friedhoff, Netherlands Chamber of Commerce, 10 Gloucester Place, London, W.1. Tel. WELbeck 9971.

***Philippine-British Trade Show.**—Wed., 11 Mar., to Tues., 17 Mar., 1959, at the Manila Hotel, Manila. Apply to the Commercial Secretary, British Embassy, Hongkong and Shanghai Bank Building, Juan Luna, Manila, Philippines.

Oil and Colour Chemists' Technical Exhibition.—Tues., 17 Mar., to Thurs., 19 Mar., 1959, at the Royal Horticultural Society's New Hall, Greycoat Street, London, S.W.1. Organised by the Oil and Colour Chemists' Association, Memorial Hall, Farringdon Street, London, E.C.4. Tel. CENtral 2120.

***Agricultural Machinery Exhibition, International.**—Tues., 17 Mar., to Sun., 22 Mar., 1959, at the Exhibition Grounds, Porte de Versailles, Paris. Organised by the Union des Exposants de Machines et d'Outillage Agricoles, 95 Rue Saint Lazare, Paris 9e. (Alteration of dates.)

***Concours Général Agricole.**—Tues., 17 Mar., to Mon., 23 Mar., 1959, in Paris. Apply to the Commissariat du Concours Général Agricole, 72 Rue de Varenne, Paris 7e. (Alteration of dates.)

***Witwatersrand Easter Show.**—Tues., 17 Mar., to Mon., 30 Mar., 1959, at Milner Park, Johannesburg. Show incorporates a United Kingdom pavilion. Organised by the Witwatersrand Agricultural Society, P.O. Box 4344, Johannesburg, South Africa.

Radio Engineering Show.—Mon., 23 Mar., to Thurs., 26 Mar., 1959, at New York Coliseum, New York. Sponsored by the Institute of Radio Engineers. Organised by William C. Copp Associates, 72 West 45th Street, New York 22, USA.

***California International Trade Fair and Industrial Exposition, First.**—Wed., 1 April, to Sun., 12 April, 1959, at the Great Western Exhibit Grounds, Los Angeles, California. Offices: P.O. Box 77610, Station D, Los Angeles 7, California, USA. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211. (Additional information.)

***International Automobile Show.**—Sat., 4 April, to Sun., 12 April, 1959, at the New York Coliseum, New York. Organised by the Charles Snitow Organization, Suite 1103, 331 Madison Avenue, New York 17, USA.

***Radio and Electronic Component Show.**—Mon., 6 April, to Thurs., 9 April, 1959, at Grosvenor House, and Park Lane House, London, W.1. Organised by the Radio and Electronic Component Manufacturers' Federation, 21 Tothill Street, London, S.W.1. Tel. ABBey 4226. (Additional information.)

FACTORY EQUIPMENT

Factory Equipment Exhibition.—Tues., 7 April, to Fri., 17 April, 1959. Also the **Heat and Sound Exhibition.**—Tues., 7 April, to Fri., 17 April, 1959. Both to be held at Earl's Court, London, S.W.5. Organised by Factory Equipment Exhibitions Ltd., 4 Snow Hill, Holborn Viaduct, London, E.C.1. Tel. CENtral 0354.

National Packaging Exposition, 28th.—Mon., 13 April, to Fri., 17 April, 1959, at the International Amphitheatre, Chicago. Organised by Clapp and Poliak Inc., 341 Madison Avenue, New York 17, USA.

***Problems of Aircraft Production, Seventh Annual Conference.**—Thurs. and Fri., 16 and 17 April, 1959, at The University, Southampton. Theme: "The Aircraft Industry—A National Asset." Promoted by the Southampton Section of the Institution of Production Engineers. IPE offices: 10 Chesterfield Street, London, W.1. Tel. GROsvenor 5254.

***Industrial Photographic and Television Exhibition.**—Mon., 20 April, to Fri., 24 April, 1959, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Organised by Trade Fairs and Promotions Ltd., Drury House, Russell Street, London, W.C.2. Tel. TEMple Bar 3422.

Films in the Service of Industry, Second Festival.—Tues., 21 April, to Fri., 24 April, 1959, at Harrogate, Yorkshire. Apply to the organising secretary, Mr. R. T. Edom, 3 Portman Chambers, 7–9 Baker Street, London, W.1. Tel. WELbeck 1104.

***Casablanca International Trade Fair, 15th.**—Fri., 24 April, to Sun., 10 May, 1959, at Casablanca. Offices: Rue Jules Mauran, Casablanca.

Electronic Parts Distributors Show.—In May, 1959, at the Conrad Hilton Hotel, Chicago. Organised by the Electronic Industry Show Corporation, Suit 1500, 11 South La Salle Street, Chicago 3, Ill., USA.

Tokyo International Trade Fair.—Tues., 5 May, to Fri., 22 May, 1959, at Tokyo. Organised by the Economic Bureau, Tokyo Metropolitan Government, Marunouchi, G.P.O Box 1201, Tokyo, Japan.

United States World Trade Fair, Third.—Fri., 8 May, to Tues., 19 May, 1959, at the New York Coliseum, New York, USA. *Managers:* The Charles Snitow Organisation, Inc., 331 Madison Avenue, New York 17. Information may be also obtained from the British Commonwealth Chamber of Commerce in the United States, 677 Fifth Avenue, New York 22. The fair's British and Commonwealth office is at 36-38 Southampton Street, London, W.C.2. Tel. TEMple Bar 8947.

Sydney Machine Tool Exhibition, Second.—Mon., 11 May, to Sat., 16 May, 1959, at the Show Ground, Sydney. Organised by the Machine Tool Division, Sydney Chamber of Commerce, 36 Grosvenor Gardens, Sydney, Australia.

Petroleum Exposition and Congress, International.—Thurs., 14 May, to Sat., 23 May, 1959, at Tulsa. Information from Mr. William B. Way, 2104, Philtower, Tulsa, Oklahoma, USA.

***Transistors and Associated Semi-Conductor Devices, International Convention.**—Thurs., 21 May, to Wed., 27 May, 1959, at Earl's Court, London, S.W.5. Organised by the Radio and Telecommunication Section of the IEE. Apply to the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. Tel. TEMple Bar 7676. In connection with this convention, an **International Transistor Exhibition** will be held, also at Earl's Court, from Wed., 20 May, to Thurs., 28 May, 1959. Organisers: Trade Fairs and Promotions Ltd., Drury House, Russell Street, London, W.C.2. Tel. TEMple Bar 3422. (Alteration of dates and additional information.)

***Waikato Winter Show.**—Tues., 26 May, to Tues., 2 June, 1959, at Blendisloe Hall of Agriculture, Hamilton. Agricultural machinery exhibits. Organised by the Waikato Winter Show Association, P.O. Box 616, Hamilton, New Zealand.

Royal Ulster Agricultural Show, 92nd.—Wed., 27 May, to Sat., 30 May, 1959, at the King's Hall, Belfast. Organised by the Royal Ulster Agricultural Society, King's Hall, Balmoral, Belfast. Tel. Belfast 665225.

***World Petroleum Congress, Fifth.**—Sat., 30 May, to Fri., 5 June, 1959, at New York Coliseum, New York, USA. Offices of the Congress: 480 Lexington Avenue, New York 17, USA. Apply to the British National Committee, Institution of Petroleum, 61 New Cavendish Street, London, W.1. Tel. LANgham 3583. (Additional information.)

***British Electrical Power Convention.**—Mon., 1 June, to Sat., 6 June, 1959, at Torquay. Organised by the British Electrical Power Convention, 26-27 Cockspur Street, London, S.W.1. Tel. WHItehall 1928. An **Electrical Exhibition** in connection with the convention will be held at Torquay during the same period. Organisers: British Electrical Development Association, 2 Savoy Hill, London, W.C.2. Tel. TEMple Bar 9434. (Additional information.)

***San Francisco International Fair, First.**—Thurs., 4 June, to Sun., 14 June, 1959, at Cow Palace, San Francisco. Offices: 325 Pacific Avenue, San Francisco 11, Calif., USA.

Oregon Centennial Exposition, Portland.—Wed., 10 June, to Thurs., 17 Sept., 1959. **International Trade Fair.**—Wed., 10 June, to Wed., 24 June. At the Pacific International Livestock Pavilion, Portland, Organised by the Oregon Centennial Commission, 400 Jackson Tower, Portland, Oregon, USA. UK inquiries to Export Publicity and Fairs Branch, Board of Trade, Theobalds Road, London, W.C.1. Tel. CHAncery 4411.

Information Processing, International Conference on.—Mon., 15 June, to Sat., 20 June, 1959, in Paris. Organised by the United Nations Educational, Scientific and Cultural Organisation. An **International Exhibition of Data Processing Equipment** will be held in Paris at the same time. Inquiries in U.K. should be addressed to the honorary secretary, Group B, British Conference on Automation and Computation, c/o the Institution of Electrical Engineers, Savoy Place, London, W.C.2 (Tel. TEMple Bar 7676); and other inquiries to the Information Processing Department, Department of Natural Sciences, UNESCO Secretariat, Paris.

COMBUSTION ENGINES

International Congress on Combustion Engines.—Mon., 15 June, to Sat., 20 June, 1959, at Wiesbaden, Germany. Theme: "**Diesel** Engines and Gas Turbines up to 1,500 **h.p.**: Current Problems Concerning Their **Design**, Production, Development and Running on Site." Apply to the secretary to the national committee, International Congress on Combustion Engines, 6 Grafton Street, London, W.1. Tel. HYDe Park 5107.

Plastics Exhibition and Convention, International (formerly the **British Plastics Exhibition and Convention**).—Wed., 17 June, to Sat., 27 June, 1959, at Olympia, London, W.14. Organised, with the support of the British Plastics Federation, 47-48 Piccadilly, London, W.1 (Tel. REGent 4681), by *British Plastics*, Dorset House, Stamford Street, London, S.E.1. Tel. WATerloo 3333.

Safety and Factory Efficiency Exhibition.—Fri., 19 June, to Fri., 26 June, 1959, at Bingley Hall, Birmingham. Offices: 71 Broad Street, Birmingham 15. Tel. Midland 8073.

***Institution of Mechanical Engineers, Summer Meeting.**—Mon., 29 June, to Thurs., 2 July, 1959, in Zürich. It is hoped that additional pleasure excursions will take place on 3 July. Institution offices: 1 Birdcage Walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

Chicago International Trade Fair.—Thurs., 2 July, to Sat., 18 July, 1959, at the Navy Pier Exhibition Hall, Chicago. Organised by the Chicago Association of Commerce and Industry, 30 West Monroe, Chicago 3, Ill., USA.

Underground Machinery Manufacturers Council, Exhibition.—Thurs., 9 July, to Sat., 18 July, 1959, at Olympia, London, W.14. Sponsored by the Council of Underground Machinery Manufacturers, c/o Peat, Marwick, Mitchell and Co. (P.O. Box 121), 301 Glossop Road, Sheffield 10. Organised by the Municipal Agency, 70 Victoria Street, London, S.W.1. Tel. VICtoria 9132.

***British Fair of Industry and Commerce, Second.**—Fri., 10 July, to Sat., 25 July, 1959, at Belle Vue, Manchester. Organised by Belle Vue (Manchester), Ltd., Belle Vue Gardens, Manchester 12. (Will not now be held.)

Design

THREE DIMENSIONAL DUCT SYSTEM

Kinematic Design for Thermal Expansion

*By J. D. Wells,**
A.M.I.MECH.E.

The use of large-diameter ducts for the transmission of hot fluids presents difficult thermal expansion problems. Ducts of this nature have considerable stiffness compared with, for instance, a steam pipe feeding a turbine with high-pressure steam, which has a comparatively small bore for high mass flows. In the steam-turbine inlet-pipe case, sufficient flexibility can usually be built into the system by arranging loops in the line. With the large-diameter ducts used, for example, on gas turbines, cross-over pipes between high-pressure and low-pressure steam turbines, coolant gas circulating pipes on nuclear reactors and chemical plant, expansion loops are not possible, because of space and economic limitations.

One method of permitting thermal expansion in this type of ducting is to anchor each end of every straight length of duct and fit an expansion bellows between the anchors. If relatively flexible bellows are used, the end reactions on the anchors will be approximately equal to the internal pressure times the area of the duct. The anchors to resist this end reaction, which can amount to many tons force, are frequently difficult to arrange; and if a machine at one end of the duct system is acting as an anchor, these loads might not be acceptable on its casing.

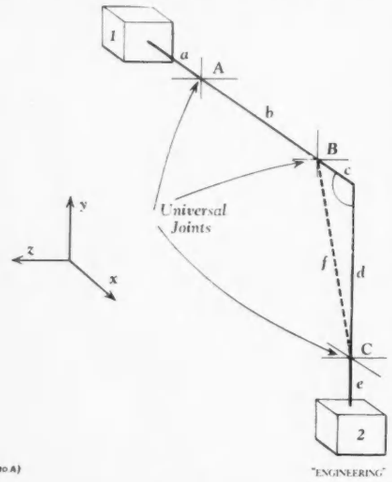


Fig. 1

Another solution to the duct expansion problem is the use of a hinged system where expansions of lengths of ducting alter the geometry of the system. The kinematic duct system described below allows for the thermal expansion of the ducts themselves, and in addition permits movement of the terminal ends of the system in the possible six degrees of freedom, three of translation and three of rotation. This will permit anchorage of hot casings at positions remote from where the ducts terminate; for instance, a turbine may be located at its high-pressure end without causing any difficulty due to linear movement of the exhaust duct as the turbine expands axially due to temperature. A further advantage of this type of system is that it allows for expansion of the various ducts in ratios not proportional to their length, i.e., a non-uniform temperature distribution in the system. The rotational freedom of the terminal ends of the system will allow, for instance, hogging or sagging of a turbine which might produce rotation of a duct flange.

KINEMATICS OF THE SYSTEM

The system consists essentially of three universal joints set in two ducts which are mutually perpendicular, as shown in Fig. 1. It can be seen that expansion of the lengths of duct in the *x y* plane, and movement of the terminal ends 1 and 2 in the *x y* plane, can be accommodated by pivoting of the joints A, B and C about their pivots lying parallel to the *z* axis.

Consider movement of end 2 relative to end 1. along the *z* axis; and for the present consider joint C to have only a single pivot lying in the *z* axis as shown in Fig. 2. Assume that all ducts lie in the *x y* plane initially and that ducts *b* and *c* are free to move relative to each other at their end B, that is, they are disconnected at the joint B. The end of the duct *b* at B can now describe a locus which is the surface of a sphere of radius equal to the length of *b*.

Since there is a single pivot at C, the end of duct *c* at B can describe a locus which is a circle of radius *f* which will lie in the *x y* plane, but this plane will be moved along the *z* axis by an amount equal to the movement of terminal end 2 relative to end 1 along the *z* axis.

Obviously the loci of the ends of ducts *b* and *c* will intersect, and this point will be the new position of joint B due to movement of terminal end 2 relative to end 1 along the *z* axis.

DETERMINING FINAL GEOMETRY

Assuming still a single pivot joint at C parallel to the *z* axis as shown in Fig. 2, the final geometry for expansions and movements, in the *x y* plane only, is shown in Fig. 3, the suffix 1 referring to this condition.

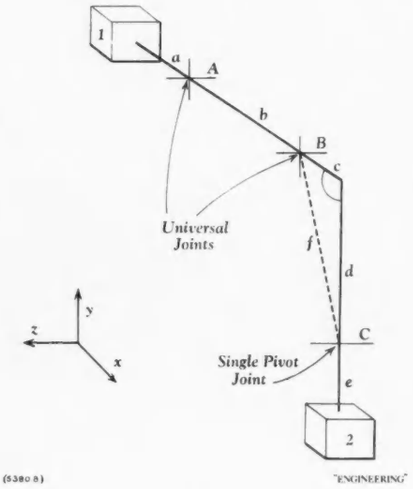
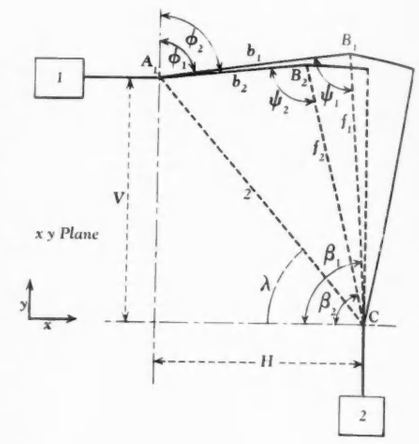


Fig. 2



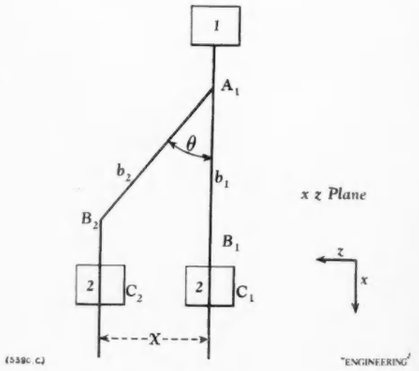


Fig. 3

Consider now movement of end 2 relative to end 1 parallel to the *z* axis, a distance X as shown in Fig. 3, the suffix 2 referring to this condition.

Referring to Fig. 3, three equations can be written down which describe the system:—

$$b_2 \sin \phi_2 \sin \theta = X \quad . \quad . \quad . \quad . \quad (1)$$

$$f_2 \sin \beta_2 - b_2 \cos \theta \cos \phi_2 = V \quad . \quad (2)$$

$$f_2 \cos \beta_2 + b_2 \cos \theta \sin \phi_2 = H \quad . \quad (3)$$

Although there are three equations and three unknowns and a solution is possible, solution of these equations would require a rather laborious iterative method. However, the angle θ is always zero initially, and since this angle will be a maximum of 1-2° in practice, we may assume that $\cos \theta = 1$ with no loss of accuracy for the purpose. This amounts to treating the geometry of the *x y* and *x z* planes separately as independent two-dimensional problems.

* Technical manager, White's of Hebburn (Engineers) Limited; formerly assistant chief engineer (components), Pametrada.

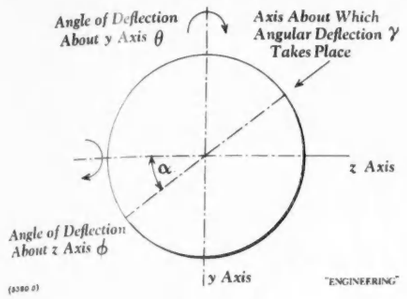

Angle of Deflection About y Axis θ
Axis About Which Angular Deflection γ Takes Place
z Axis
α
Angle of Deflection About z Axis φ
y Axis
"ENGINEERING"

Fig. 4

Equations (2) and (3) may now be written

$$\sin \beta_2 = (V + b_2 \cos \phi_2) \frac{1}{f_2} \quad . \quad (4)$$

$$\cos \beta_2 = (H - b_2 \sin \phi_2) \frac{1}{f_2} \quad . \quad (5)$$

Combining (4) and (5)

$$\frac{1}{f_2^2}[(V + b_2 \cos \phi_2)^2 + (H - b_2 \sin \phi_2)^2] = 1 \quad (6)$$

Hence from (6)

$$H \sin \phi_2 - V \cos \phi_2 = Z \quad . \quad (7)$$

where

$$Z = \frac{V^2 + H^2 + b_2^2 - f_2^2}{2b_2}.$$

From (7) $\sin (\phi_2 - \lambda) = \dfrac{Z}{\sqrt{V^2 + H^2}}$. (8)

where $\lambda = \tan^{-1} V/H$.

The procedure for calculating the final geometry of the system is as follows: (1) Calculate final values of V and H projected on to the $x\,y$ plane; these will be the initial values with allowance made for the expansion of a and e. (2) Calculate the expanded lengths b_2 and f_2 and evaluate Z. (3) Evaluate ϕ_2 from equation (8); β_2 and θ may be evaluated by substituting the value of ϕ_2 in equations (4) and (1), respectively. (4) The deflection of the joints A and C about axes parallel to the z axis may be determined from the differences between β and β_2, and ϕ and ϕ_2. (5) The value of $\Delta\psi$, the angular deflection of joint B about the z axis, may be determined by the difference between the initial value of ψ, and ψ_2, where $\psi_2 = 90 + \phi_2 - \beta_2$.

Joints A and B allow pivoting about the y axis also and this deflection is equal to θ. If γ is the angle between axes of the ducts a_2 and b_2 (when projected within a plane), and is equal to θ in the $x\,z$ plane and ϕ_2 in the $x\,y$ plane, then the value of γ, for small values of θ and ϕ, is given by

$$\sin \gamma = (\cos \alpha \sin \phi + \sin \alpha \sin \theta) \quad . \quad (9)$$

where α is the angle about the axis for which the projected angle between the ducts, γ, is evaluated. See Fig. 4.

By differentiation of equation (9), γ is a maximum when

$$\tan \alpha = \frac{\sin \theta}{\sin \phi} \quad . \quad . \quad (10)$$

Hence, by substituting (10) in (9),

$$\sin \gamma_{max} = \sqrt{\sin^2 \phi + \sin^2 \theta} \, . \quad (11)$$

This angle γ_{max}, is the angle through which the flexible element of the gimbal bellows will be deflected.

PRACTICAL LIMITATION OF SINGLE PIVOT JOINT

It has been assumed in the analysis that there is a single pivot only at C pivoting in the z axis, as shown in Fig. 2. Provided that perfect ball joints could be used at A and B, that is, joints which do not produce relative motion of the ends when they are flexed, then the single pivot at C would be satisfactory. This would be possible if the joints consisted of untied bellows connecting the two ducts together; however, the high axial-pressure force would have to be resisted by a very stiff bellows, which defeats the object of a flexible duct system.

It is apparent that the flexible joint must carry these high axial-pressure loads, not through the flexible element, but through some form of linkage. The Hooke's joint type of linkage is the most suitable, but immediately introduces a complication, because a Hooke's joint produces relative rotation of input to output shaft axes, when it is deflected so that there is rotation of both pivot axes of the joint.

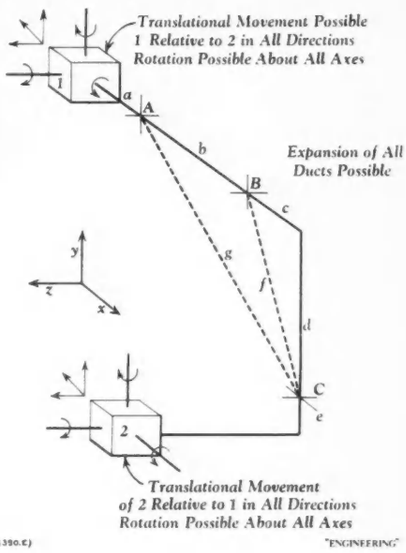

Translational Movement Possible
1 Relative to 2 in All Directions
Rotation Possible About All Axes
Expansion of All Ducts Possible
Translational Movement
of 2 Relative to 1 in All Directions
Rotation Possible About All Axes
"ENGINEERING"

Fig. 5

The expression governing this relative rotation is:

$$\text{Tan } \alpha_i = \cos \gamma \tan \alpha_o$$

where

γ = angle of flexure.
α_i = angle of pin axis of input shaft to plane of flexure.
α_o = angle of pin axis of output shaft to plane of flexure.

This may be written:

$$\Delta \alpha = \alpha_i - \tan^{-1} \frac{\tan \alpha_i}{\cos \gamma} \, . \quad . \quad . \quad (12)$$

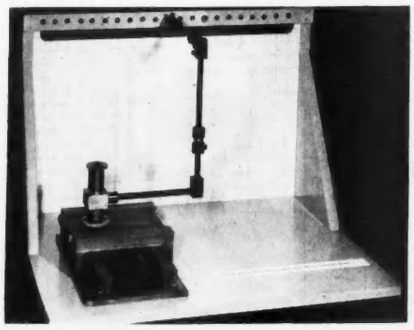
Obviously, if there is no flexure about an axis lying between the pivot axes, then

$$\alpha_i = 0 = \alpha_o$$

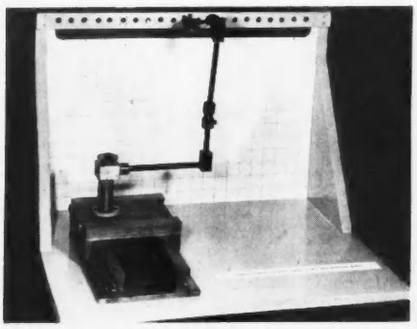
and there is no relative rotation.

For duct applications, the angle γ is limited

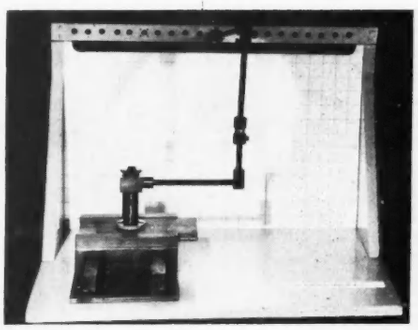
Fig. 6 Demonstration model of duct system.



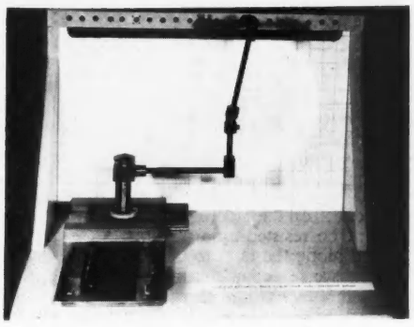
(*a*) Initial condition.



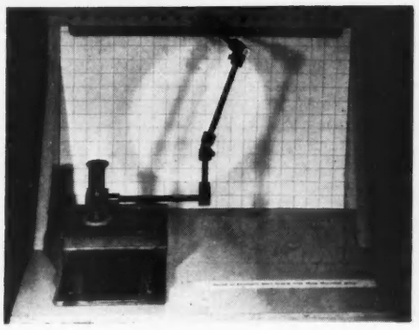
(*b*) Deflection along $x\,y$ axis.



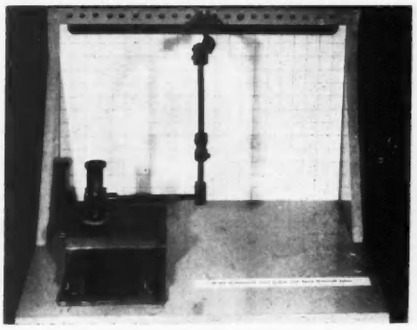
(*c*) As in (*b*), but with deflection along z axis (pivot pins parallel).



(*d*) As in (*c*), but with pivot pins at 90°.



(*e*) As in (*a*), but with duct *a* rotated through angle ω.



(*f*) As in (*a*), but with duct *e* rotated through angle ω.

Continuing **Design**

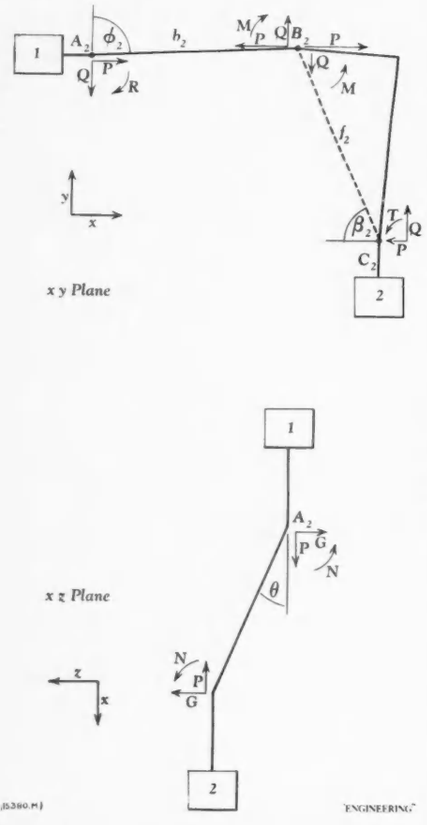
to about 3° of arc which produces a relative rotation of about 2 minutes of arc if the plane of flexure is at 45° to the pivot axes.

The net rotation of a pair of Hooke's joints coupled together with an intermediate shaft is zero, provided that the pivots attached to each end of the intermediate shaft are parallel and the end shafts are deflected through the same angle in the same plane. In the case of the ducts, the net rotation will not be zero because, while θ is equal for both joints, the deflections about the z axis, $\Delta\phi$ and $\Delta\beta$, are not equal. However, provided that the pivot pins attached to each end of the duct b are parallel, the relative rotation of one joint will counteract the other to some extent. If the pivot pins are at 90° to each other, the relative rotation of each joint will be additive.

Referring back to Fig. 2, it can be seen that if terminal end 2 is moved in along all three axes of translation, then flexure about an axis lying between the pivot axes of joint A and B will occur and a rotation will be produced, but duct c cannot rotate about its x axis to allow this because it is pivoted at C by only a single pivot lying in the z axis. Therefore it is clear that a joint pivoted parallel to the x axes as well as the z axis is theoretically required at C to allow free rotation of duct c about its own axis by pivoting of the joint C about the x axis. The effect of this small rotation of joint C about an axis parallel to the x axes will have only a negligible effect on the geometry of the system as determined by the previous analysis.

In a practical duct system, it will usually be found that the net relative rotation of the two joints is so small that a small torque in ducts a, b and c, together with a resisting couple in ducts d and e, will produce sufficient deflection to satisfy the geometry of the system using only a single pivoted joint at C. If rotational movement of end 2 is required about the x axis, a double pivot at C will be required.

Figs. 7 and 8



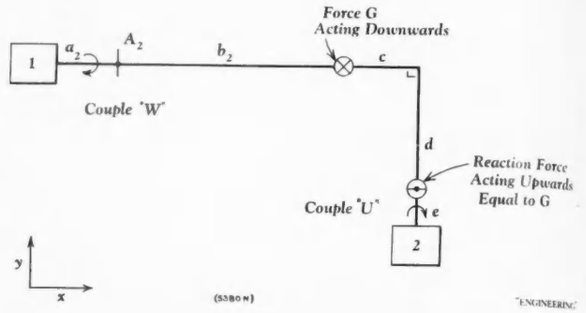


Fig. 9

Fig. 5 shows the complete system, with a double pivoted joint at C, showing that all movements and expansions are possible. Rotational movements of end 1 about the y and z axes and rotation of end 2 about the x and z axes may be considered simply as a rotation and translational movement at A and C respectively. This rotation will be accommodated by extra angular deflection of the joints and the translational movement by a change of geometry in the $x\,y$ plane.

Small rotations of end 1 about the x axis can be allowed by equal rotation of duct d about the x axis at C; the new lateral position of B can be determined and all other effects may be ignored. Similar reasoning may be applied to rotation of end 2 about the y axis. To avoid undue lateral movements due to end rotation, the joints should be arranged so that the terminal end which suffers most rotation is end 2, adjacent to joint C. The lateral movement of B due to a rotation of duct a equal to ω is roughly equal to $\omega\,d$, whereas for rotation of duct e the lateral movement of B is only $\omega\,c$.

A small demonstration model of the system has been made and is shown in Fig. 6. It has three universal joints, as in the system in Fig. 5, and is arranged so that one end can be moved independently in each of three mutually perpendicular directions. Fig. 6 (*a*) shows the system initially; Fig. 6 (*b*) shows movement of one end along the x and y axes. Movement along the z axis has taken place in Fig. 6 (*c*) in which the joint pivots joined to duct b were in line. Fig. 6 (*d*) shows the larger tilting effect on d due to the pivots at the ends of duct b being at 90° to each other, the relative rotation of joints A and B being additive instead of counteracting as in Fig. 6 (*c*). In Fig. 6 (*e*) duct a has been rotated about its axis, and the large lateral deflection of B can be seen. The smaller lateral deflection of B when e is rotated about its own axis is shown in Fig. 6 (*f*).

ANGULAR STIFFNESS OF JOINTS

Two-Dimensional System

In considering the forces acting on the duct system, the weight of the ducts and joints may be ignored, since these would be taken by constant load hangers. The couples acting in the ducts between end 1 and A_2 and between end 2 and C_2 are known, since these are equal to the moments necessary to deflect joint A by $\Delta\phi$ and B by $\Delta\beta$; let these be R and T respectively. The moment at B_2 must similarly be equal to the moment necessary to deflect joint B_2 by $\Delta\phi$; let this be M.

Referring to Fig. 7 and taking moments about B_2, for duct b_2:

$$P\,b_2\cos\phi_2 + Q\,b_2\sin\phi_2 - R = M \quad . \quad (13)$$

$$P\,f_2\sin\beta_2 - Q\,f_2\cos\beta_2 - T = M \quad . \quad (14)$$

By combining (9) and (10):

$$P = \frac{f_2\cos\beta_2(M+R) + b_2\sin\phi_2(M+T)}{f_2\,b_2\cos(\phi_2-\beta_2)} \quad . \quad (15)$$

Similarly

$$Q = \frac{f_2\sin\beta_2(M+R) - b_2\cos\phi_2(M+T)}{f_2\,b_2\cos(\phi_2-\beta_2)} \quad . \quad (16)$$

The resultant of P and Q, will be given by

$$\sqrt{P^2+Q^2}$$

and will act at an angle of $\tan^{-1}Q/P$.

It should be noted that the arrows in Fig. 7 at A_2 and C_2 indicate the direction of the forces acting on the ducts; the reactions acting on the ends 1 and 2 are in the opposite direction.

Three-Dimensional Movement

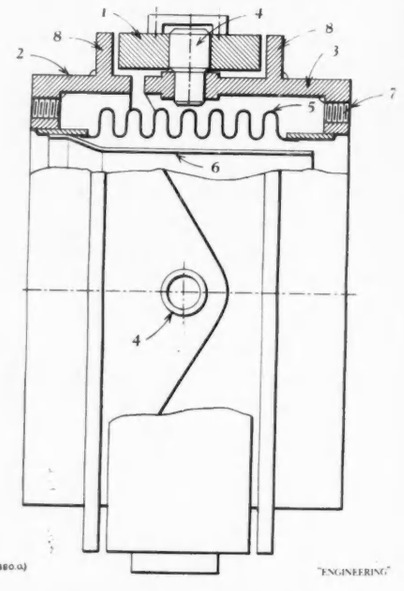
Considering now movement of terminal end 2 relative to end 1 parallel to the z axis. The pivoting of joints A and B about the y axis produces couples and forces at these points due to the joint stiffness; the direction of these couples and forces is shown in Fig. 8. The value of this couple is given simply by the angle of deflection at A or B times the angular deflection rate of the duct joint,

$$N = \theta\,G \quad . \quad . \quad . \quad . \quad . \quad . \quad (17)$$

where N = couple as shown in Fig. 8
G = angular deflection rate of joint, lb-in per degree

The value of the force P is already known; the other force G may be calculated from the

Fig. 10 Gimbal bellows flexible joint.



following equation for values of ϕ_2 close to 90°,

$$G\,b_2\cos\theta + p\,b\sin\theta = 2N$$

The effect of the sideways force G acting at B cannot be resisted by a transverse couple transmitted along the duct to the fixed end, because a transverse couple cannot be transmitted through a Hooke's joint without angular deflection of its pivots. The moment due to force G must be resisted by couples acting about the axes of ducts a and d; this is shown in Fig. 9.

Assuming that ducts *a*, *b* and *c* are in line and perpendicular to ducts *d* and *e*, then couple W is equal to G . *d* and prevents rotation of the pivots of the joint at C about an axis parallel to the *x* axis. The couple U equals G . *c* and prevents the rotation of the pivots of joints A and B about an axis parallel to the *z* axis.

DESIGN OF UNIVERSAL JOINTS OR GIMBAL BELLOWS

A diagrammatic drawing of a suitable gimbal joint is shown in Fig. 10; item 1 is the gimbal ring to which both end casings 2 and 3 are pivoted by pins 4. The bores of the end casings 2 and 3 are joined by a flexible element 5 which is fitted with a shield 6 to prevent aerodynamically excited vibration of the convolutions which has been known to cause a fatigue failure of the flexible element. The ducts between which the flexible joint is fitted are bolted to the tapped holes 7 in the end casings. Stops 8 are fitted to the periphery of the end casings 2 and 3, to prevent excessive deflection of the flexible element during erection of the pipework. The gap between the stops and the gimbal ring provides a useful method of gauging the angular deflection of the joint.

The loads carried through the pins, which are roughly equal to the internal pressure times the cross sectional area at the outer radius of the bellows, are quite high for even moderate pressures, and the stressing of the gimbal ring ends must be carefully carried out. The two pairs of forces acting on the ring are in opposite directions across diameters which are perpendicular to each other; this produces a maximum bending moment at the position of each pin on the circumference, and a maximum torsional moment occurs mid-way between the pins. Thus for minimum stress and deflection, the ring section must be adequate from both the bending and torsional aspect. The ring is very flexible when loaded in this manner, and for reasonable stress levels the deflection due to the loads will be of a similar order to axial deflection of the flexible element due to angular movement.

If the flexible element is of the U type as shown in Fig. 10 it must be of small convolution height and be made from a thin section material if a reasonable flexibility is to be obtained. This is due to the necessity of keeping the radial bending-moment stresses, which are due to both pressure and longitudinal deflection, at a reasonable level.

PRACTICAL EXAMPLE

Geometry of the System

Assume a duct layout as shown in Fig. 11 operating at a temperature rise of 1,000° F. with a coefficient of linear expansion of $7{\cdot}0 \times 10^{-6}$ per °F. The ducts are 22 in diameter and 0·25 in thick and the gimbal joints have a moment/angular deflection rate of 5,000 lb-in per ° of arc.

Ducts *a* and *e* expand by 0·175 in, therefore

$$H = 124{\cdot}825 \text{ in and } V = 49{\cdot}825 \text{ in}$$

Using the expanded lengths of the ducts to evaluate Z in equation (7)

$$Z = 124{\cdot}306 \text{ in}$$

Substituting this in equation (8) with the values of H and V

$$\sin^{-1}(\phi_2 - \lambda) = 67{\cdot}66°$$
$$\lambda = \tan^{-1} V/H = 21{\cdot}75°$$
$$\therefore \quad \phi_2 = 89{\cdot}42°$$

From equation (4)

$$\beta_2 = 64{\cdot}58°$$
$$\psi_2 = 90 + (\phi_2 - \beta_2) = 114{\cdot}84°$$

Using the unexpanded lengths of the ducts, and H and V in equation (7) and (4), the initial values of angles ϕ and β may be determined.

Then $\phi = 90°$: $\beta_2 = 63{\cdot}635°$: $\psi = 116{\cdot}565°$

By difference the angular deflection are as follows:—

$$\Delta\phi = 0{\cdot}58°: \quad \Delta\beta = 0{\cdot}845°: \quad \Delta\psi = 1{\cdot}725°$$

From equation (1), $\theta = 0{\cdot}2°$. Therefore the joints at A and B will be deflected 0·2° about axes parallel to the *y* axis.

The resultant deflections of the joints at A and B due to deflection about the *z* and *y* axis, as calculated from equation (11), are as follows:—

Joint A: 0·614°
Joint B: 1·737°

The rotation of the duct *c* about it own axis, relative to duct *a*, due to the deflection of joints A and B about both their *y* and *z* axes, is about 0·006°, provided that the pivot pins attached to each end of duct *b* are parallel. This is the angle through which the *x* axis pivot of joint C will rotate. If a single pivot in the *z* axis of joint C were used, a torque of about 1,000 lb-ft would be developed in the ducts *a*, *b* and *c*, assuming no slackness in the pivots of the joints. However, this torque has to be transmitted between four sets of pivots and a total rotational movement of about 0·002 sec at the radius of the pins would relieve the torque completely. It would be unnecessary to fit a double-pivoted joint at C unless rotational freedom about the *x* axis were required at end *z*.

Forces and Moments on the Ends of the System

The x y Plane.—The end couples T and R are known, since they are equal to the angular deflection of joints A and C respectively, times the moment rate of the joint. The value of the moment M is obtainable by a similar process.

$R = 0{\cdot}58 \times 5{,}000 = 2{,}900$ lb-in
$T = 0{\cdot}845 \times 5{,}000 = 4{,}225$ lb-in
$M = 1{\cdot}725 \times 5{,}000 = 8{,}625$ lb-in

Substituting these values and the angles β_2 and ϕ_2 in equation (15) P = 307·5 lb.

Similarly using equation (16) Q = 112·4 lb.

Thus the resultant is 327 lb and acts at an angle of 21·5° from the horizontal at A_2 and C_2.

The maximum direct thrust on the system is therefore 327 lb but this force will produce a relatively high moment at 1 of 16,350 lb-in,

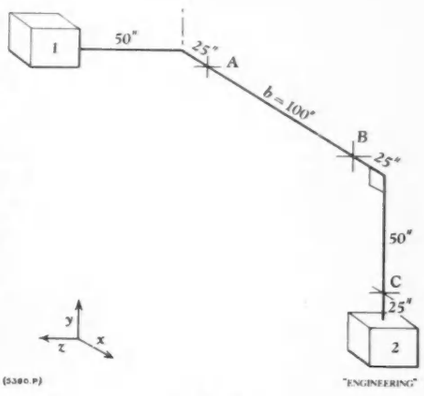


Fig. 11

and for this reason the joint C would normally be placed in the longest duct terminating the system.

The x z Plane.—The couples N acting in the *x y* plane are given by equation (17)

$$N = \theta G = 0{\cdot}2 \times 5{,}000 = 1{,}000 \text{ lb-in}$$

The lateral force

$$G = \frac{2N}{b_2} - P \sin\theta = \frac{2{,}000}{1{,}007} - 307{\cdot}5 \sin 0{\cdot}5°$$

$$G = 17{\cdot}18 \text{ lb}$$

The couple W acting about the axis of a_2 at terminal end 1,

$$W = Gd_2 = 17{\cdot}18 \times 50{\cdot}35 = 920 \text{ lb-in}$$

The other couple at end 2,

$$U = Gc = 17{\cdot}18 \times 25{\cdot}18 = 432{\cdot}5 \text{ lb-in}$$

Acknowledgement.—The article has been published with the kind permission of Dr. T. W. F. Brown, director of Pametrada Research Station.

COMMUNICATIONS SYSTEM *for* MISSILE SITE

A contract valued at £6,000 has been awarded to Amplivox Industrial Division for the control communication system in the new rocket-site at Spadeadam, in Cumberland. This Group Communication System which was specially designed for the Spadeadam project can provide 24 persons with communication channels of high speech intelligibility. The system is, however, very adaptable and has many and varied inter-communication applications where normal telephonic communication is impracticable because of adverse conditions.

The Amplivox Communication System is in effect a high volume telephone circuit in which up to 24 persons can be in direct communication. Each " station " comprises a lightweight headset, line amplifier and lead assembly. With the system, virtually any of the Amplivox range of headsets can be used, depending on the application and operating conditions. This includes headsets with noise-cancelling microphones and with rigid-wall ear defenders. The particular headset supplied for the Spadeadam rocket-site project is a single earphone version which can be mounted under a safety helmet, and the micro phone boom arm has been angled to allow it to clear the rim of the helmet in its traverse to the parked position above the head. An Amplivox noise-cancelling microphone is also used.

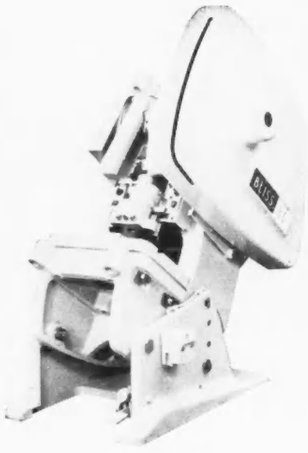
Each headset carries in its connecting lead a small tubular transistorised line amplifier, the approximate dimensions of which are: length 4 in, diameter 1½ in. The line amplifier consists of a three-stage microphone amplifier and a single-stage earphone amplifier. It also contains a " side tone " balancing transformer which is designed to cause the speaker to hear his own voice at reduced level, as a result of which his speaking level is high and gives the system a good signal-to-noise ratio. The line amplifier is attached to the wearer's clothing by means of a clip and sufficient lead is provided between the headset and amplifier for it to be clipped at belt level.

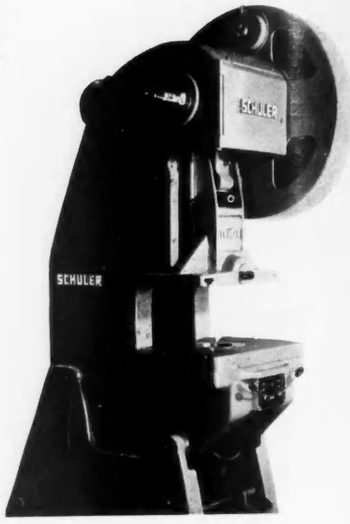
From the line amplifier the headset lead continues to a suitable plug which can be immediately plugged into any of the socket outlets on the installation site. The system uses a two-wire line, screened and balanced about earth. The central apparatus is contained in a " supply unit " which consists of a supply battery (about 18 volts) and a simple choke transmission bridge. The supply unit can be connected across the line at some convenient central point in the installation. With this simple central apparatus, each station is virtually self-contained, and there is no need for a central amplifier. If a fault does occur at any one station the remainder of the system is not affected.

The line length can be up to about 1,200 ft and Amplivox recommend a twisted pair of 23/0·0076 in conductors, screened overall. The line length of the system can be greater provided the limits of loop resistance and capacitance are not exceeded. The frequency response rises at approximately 10 dB per octave from 300 c/s to 1,500 c/s; is nominally level from 1,500 c/s to 3,000 c/s; and has sharp cut-off below 300 c/s and above 3,000 c/s. As compared with the gain which exists with the minimum of two headsets on the line, the system gain does not fall by more than 6 dB when twelve headsets are connected to the line.

Continuing **Design**

THE LOOK OF THINGS





Two approaches to the design of an open-fronted inclinable power press: the British Bliss and the German Schuler.

Largely owing to increasing competition from the Continent, engineering industry in Britain is beginning to devote more attention to the look of its products. Some firms are employing staff industrial designers as part of the design team; others make use of the services of industrial design consultants; others prefer to encourage their engineering designers to cope also with the problem of good appearance; but there still remain those—and there are many of them—who feel that appearance and styling is irrelevant to engineering.

Senior executives from, at any rate, the first three categories met recently to discuss " Industrial Design and the Engineering Industries " at a one-day conference held at the Birmingham Exchange and Engineering Centre. The conference was organised by the Council of Industrial Design; Mr. Whitney Straight, C.B.E., M.C., D.F.C., deputy chairman of Rolls-Royce Limited, was in the chair. The opening address, on " The National Importance of Good Industrial Design," was given by the Minister of Power, the Rt. Hon. Lord Mills, K.B.E., who said that the well-finished article, designed to please the eye and to give the promise of its performance, would always command a greater market and more money. The other lecturers are listed at the end of this review. Accompanying the conference was an exhibition of photographs of well-designed engineering products from Britain and Europe; a selection is reproduced here.

The present state of the art of " appearance design " in engineering was well summarised by Mr. Misha Black, and we cannot do better than quote his words:

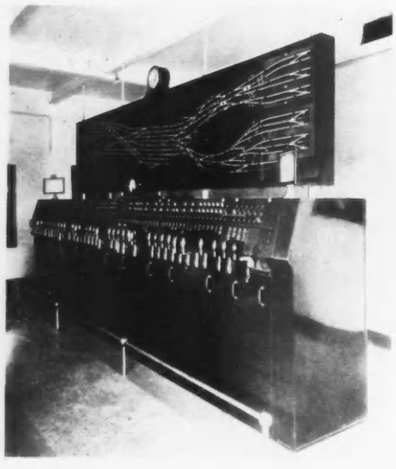
" Many of the best designs produced during the last 100 years by the engineering industries have been the work of mechanical or electrical or railway engineers whose visual judgment has been impeccable, whose intuitive sense of form has controlled their work from the lay-out of its mechanical parts to the detailing of the casework or the decorative enrichment which was the pride of the Victorian inventors.

" But now that certainty of touch has been vitiated, partly by the greater subdivision of function in the engineer's office, partly by the general loss of the sense of artistic direction in our whole civilisation, partly by the consideration of design as a sales gimmick, partly by a general tendency to enclose mechanisms within casework which is not of necessity directly related to the mechanism itself.

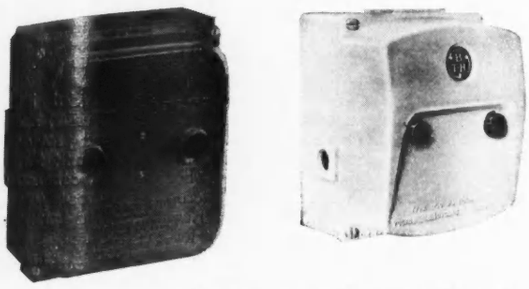
" In these unhappy circumstances the engineer, when he is free from the most rigid technical specification . . . tends to flounder. He compensates for his lack of visual design conviction either by scant attention to this less essential aspect of his production, or asserts his authority by a proud display of chromium plate, speed whiskers or those curiously depressed eyebrows which now too often deface the elegant noses of diesel and electric locomotives.

" There are, of course, brilliant exceptions to this rule and a time may well come when the formal visual qualities of industrial production will again unerringly equal the mathematical beauty of its essential parts; when, without self-conscious design effort, the exterior case of a television set will always provide visual satisfaction equal to that to be gained from inspecting its intricate interior, when the interior fittings of an aircraft will always be as satisfactory as its aerodynamic form, when the massive bulk of a power press will always be as impressive as its performance. In the meanwhile we must do the best we can."

Granted this premise—and certainly the majority of the engineers who took part in the discussions seemed all too ready to disclaim any pretensions to artistic ability—then there is a case for employing the " appearance designer " who has been trained in the fine arts and their industrial application. Whether a staff designer or a consultant is employed, there is general agreement that to be effective he must come in right at the start of the project and must be an integral part of the design team. It seems to the reviewer, however, that this dependence on a specialist " appearance " designer is satisfactory only as an interim measure. Unless the senior executives responsible for design policy can develop a justified confidence in their own ability to lead their teams and infuse their own sense of what is good overall design—not separated into " engineering " and " appearance " compartments—then Britain cannot expect to retain her position as a leader of engineering industry. Analagous views have already been expressed many times, of course, by Mr. Hugh Clausen and notably in his address earlier this year to



Railway signalling frames before and after redesign at Potters Bar. Metropolitan-Vickers Electrical Co. Ltd.



Contactor starter before and after redesign. British Thomson-Houston Co. Ltd.

the Institution of Engineering Designers (ENGRG, 20 Jun. '58, p. 791).

That it is still possible for engineering designers to create machines of satisfying appearance in the modern idiom was shown in the slides accompanying the lecture on power presses by Mr. Schuler; one of these, an inclinable press, is reproduced opposite, and it is interesting to compare it with the Bliss inclinable press, with its off-square flywheel housing—the result of co-operation with a consultant industrial designer.

In the power press department of Vickers-Armstrongs (Engineers) Limited, also, the overall design approach by the engineer designer is favoured although, to quote from Mr. Anderson's paper, " If you honestly feel that you do not have suitably qualified staff . . . or time is against you, by all means call in consultant industrial designers, there is no shame in it." But, basically, his contention—and we agree—is that good design is synonymous with good appearance. He said:

" The designer who does not achieve both is lacking in the ability to form a picture in his mind's eye of the machine, not just on paper, but in operation in the customer's plant . . . The prime necessity is to give the designer as much opportunity as possible to meet the customers on their own ground . . . Of course, the only long-term policy to follow is to catch 'em young and train them. . . .

" Budding designers should be given every opportunity to follow the product through all stages from assembly to shop trials, through dismantling, where so many irritating snags are found, to despatch; a period as service engineer, where they will hear exactly what customers think of them first hand, and a period of duty as staff engineer at the beck and call of every salesman and selling agent who has a customer after his blood. Combine this experience with a tour of duty on technical sales and the end product will be first class designers with a full understanding of the other fellow's problems, a clear picture of the industry as a whole, and the ability to create something more than an efficient piece of machinery."

There is, however, another aspect to the employment of the consultant industrial designer in the case of a large group of firms, for which a strong argument can be developed. The companies associated with AEI, for example, range over a very wide field of electrical gear, and to ensure a unified design policy there must be a co-ordinating influence. Here, the outside consultant can be of great service, provided that the staff engineer designers are prepared to co-operate. This problem of co-operation, which can be formidable if it is mishandled, is usually easily settled if the engineer designers are encouraged to appreciate the importance of a good integrated appearance of all the firm's products. In the AEI group, there are various schemes for doing this. In some companies, a brief course of industrial design is introduced into the drawing office apprenticeship course, and in other companies illustrated design lectures are given to engineers and draughtsmen. This year, for the first time, AEI have organised their own industrial design conference.

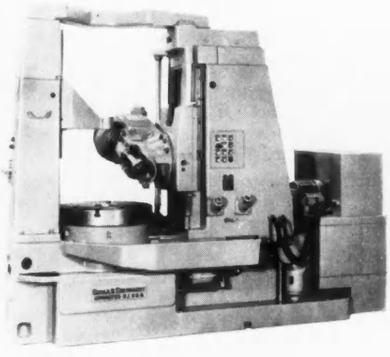
Other firms too are introducing industrial design into their apprenticeship courses—but the general, and depressing, conclusion is that not more than 3 per cent of the trainees show signs of any promise of creative industrial design ability. This supports Mr. Clausen's contention that engineering design is now rated so low in the " status " scale that creatively-minded young engineers tend to avoid service in the drawing office. This too would seem to be borne out by a surprising statement by Mr. Black that few engineer designers can visualise the appearance of the final product in the early stages. Surely it is even more difficult to visualise an intricate three-dimensional mechanical linkage, and if the engineer is unable to visualise it, how on earth can he design it so that it works efficiently?

One speaker in the discussion referred to " the intrinsic beauty of a good balance sheet," and throughout the conference there recurred the theme " our products must have a good appearance so that we can sell them overseas." Of those present, only Dr. Seward of W. and T. Avery Limited expressed the wider view that " good design is an indispensable part of civilised life. . . ."

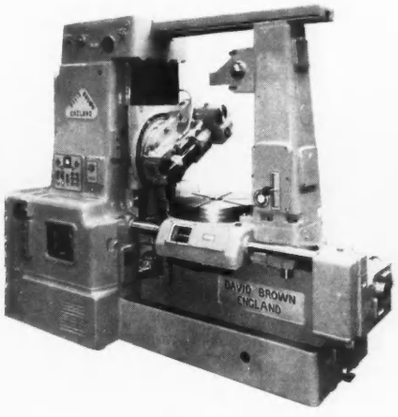
Avery have for the past 25 years been using the services of a consultant industrial designer. One of the advantages they claim for the outside consultant is that, being concurrently engaged on design work throughout a wide range of manufacturing industries, he is well informed on new uses of materials and manufacturing processes; he is thus far more likely to introduce new concepts and to be less inhibited by an employer's known preferences. But is this last factor an advantage? Why shouldn't the manufacturer have his own firm's individuality impressed upon his products?

Most of the firms who are consciously in pursuit of good product appearance are aware of the need to extend good design to cover sales promotion and presentation. (Have they really looked at the permanent display at the Birmingham Exchange and Engineering Centre where the conference was held? This could well be a starting point for some re-thinking on presentation.) As Sir Gordon Russell pointed out, " It is becoming increasingly important to have a lively sense of design trends not only as regards your products . . . but also in relation to the face which you present to the world through the design of . . . catalogues, stationery, exhibition stands, offices, showrooms and works, canteens, delivery vehicles." It is here that the outside industrial design consultant really comes into his own as a unifying influence.

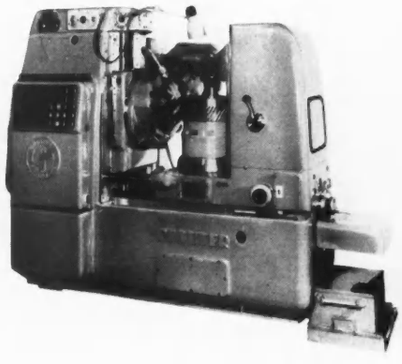
Three approaches to the design of a gear hobbing machine: American, British, German.



American



British



German

CONFERENCE LECTURES

" Industrial Design within AEI," by Mr. G. S. C. Lucas, O.B.E., director and chief electrical engineer, British Thomson-Houston Company Limited;

" Appearance Design of Power Presses," by Mr. Louis Schuler, managing director, L. Schuler A/G, Goppingen, Germany;

" Industrial Design in Heavy Engineering," by Mr. John Anderson, manager, Power Press Dept., Vickers-Armstrong (Engineers) Limited, Newcastle upon Tyne (read by Mr. A. Ashley);

" The Role of the Industrial Designer," by Mr. Misha Black, O.B.E., senior partner, Design Research Unit;

" The Engineer and the Industrial Designer," by Dr. E. W. Seward, technical manager, W. & T. Avery Limited;

" The Role of the Council of Industrial Design," by Sir Gordon Russell, C.B.E., M.C., director, Council of Industrial Design.

Continuing **Design**

STEAM *for 550 MW*

In the eight months that have elapsed since the contract for the 550 MW boiler was awarded to International Combustion Limited, 19 Woburn Place, London, W.C.1, considerable advance has been made in the detail design and perhaps in particular in the matching of the boiler performance to the requirements of the C. A. Parsons turbines that will be supplied. At a recent Press conference, International Combustion gave a resumé of the design as it stands at present. It will be recalled that the steam conditions for the plant (which is to be installed at the Thorpe Marsh station of the CEGB) are 2,400 lb per sq. in at 1,055° F with one stage of reheat to 1,055° F. Temperature of feed water 496° F. Evaporation will be 3,750,000 lb per hour at a guaranteed efficiency of 90 per cent, based on the gross calorific value of the fuel. Notes on the boiler were published previously in ENGINEERING for 28 February, 1958, page 287, and on the turbines 9 May, page 586.

Coal will be supplied from the local pits but it is expected that some will have to be brought from the East Midlands. Both sources have a rather high chlorine content (the latter particularly so) which makes for fouling of the furnace. The coal will in the main consist of "washed fines" of calorific value from 8,300 to 12,000 Btu per lb, with ash content up to 40 per cent and moisture up to 20 per cent. In view of the enormous consumption of about 205 tons per hour, very large handling facilities will obviously be required, but particulars of these are not yet available. In their normal state washed fines are extremely sticky and have be handled as a rule by grabs. They also tend to cake in bunkers, necessitating very large delivery openings.

Basically the boiler consists of two main furnaces with one controlling the steam temperature and the other the reheat temperature. Both are subdivided again into two parts. Special points of interest are the forced circulation and the milling equipment, both of which have had to be made very large, in the latter case to avoid having many small units. Some details of both are given below. The superheaters were designed in conjunction with the Superheater Company Limited and have special provision for balancing the load. Temperature recorders are fitted to indicate the metal temperatures. It is expected that work on site will commence about the end of 1960; before that date some 100,000 man hours will have been spent in the drawing office alone, apart from about 12,000 on detail work.

on account of variable external fouling of the heating surface.

Although the boiler is divided into two separately cased twin furnace units, each subdivided by a partition wall and provided with two steam release drums, the unit forms one single entity with both drums connected into the circulating system of the furnace so that the system operates as a unified and balanced unit with a single water level control.

The water from each drum is extracted by equal downcomer legs to centrally positioned circulating pumps discharging in turn to a common manifold. From there multiple feeder tubes supply both furnaces while the risers forming the furnace walls discharge equally to both drums. The steam output from both

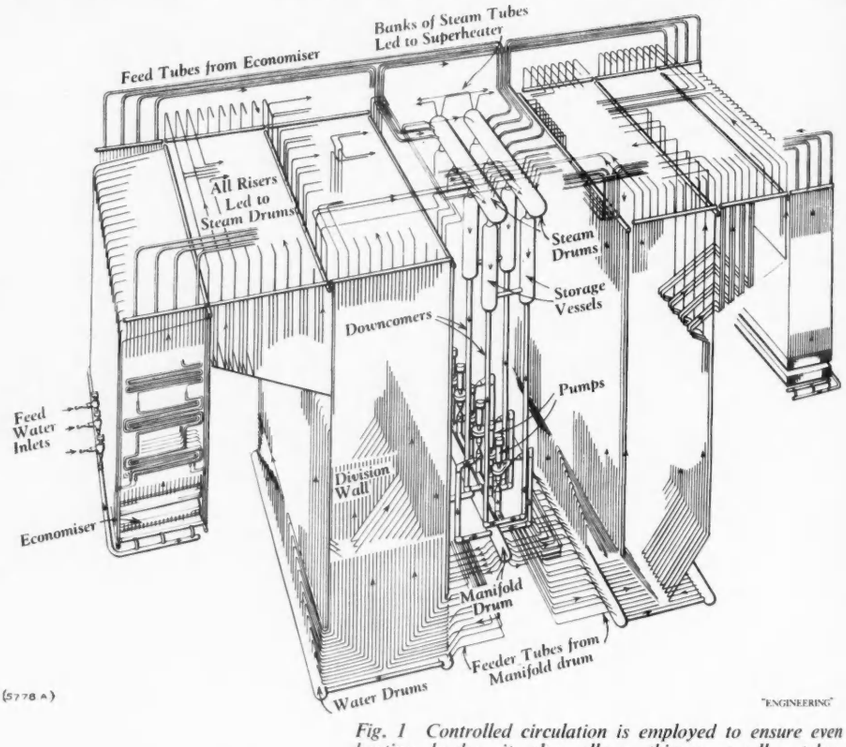


Fig. 1 Controlled circulation is employed to ensure even heating loads; it also allows thinner, smaller tubes.

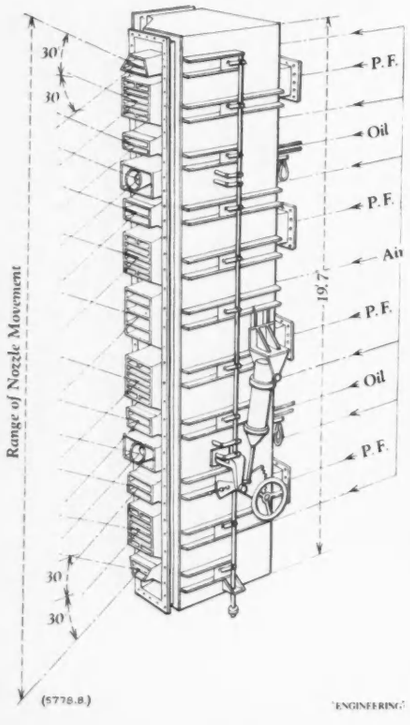


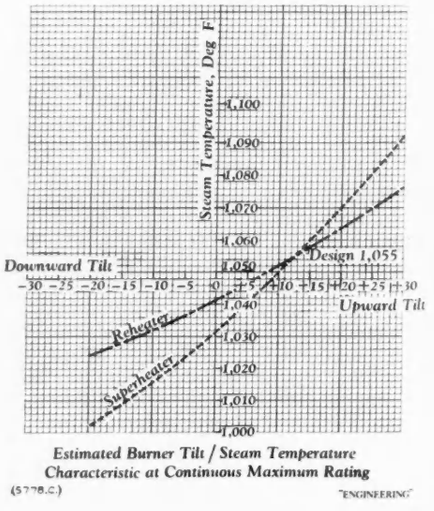
Fig. 2 The corner burners can be tilted to vary the heat input.

CIRCULATING SYSTEM

The adoption of controlled and assisted circulation follows logically on other current designs in which the natural circulation potential, due to the thermal head, is augmented by a pumping system. This system permits smaller bore tubes to be used for both risers and dowcomers, and the consequent use of a thinner wall and reduced temperature gradient across it enables safety of operation and economy of capital cost to be achieved simultaneously. A diagram of the circuit is shown in Fig. 1.

The water supplied to each evaporating circuit is matched to the calculated heat absorption of each individual circuit by control nozzles. These nozzles improve circulating stability of the circuit, so that wide fluctuations of heat absorption do not result in over-heating of the tube metal

Fig. 3 Curves showing the temperature variation obtainable by tilting burners.



Estimated Burner Tilt / Steam Temperature Characteristic at Continuous Maximum Rating

furnaces is, therefore, equally distributed to both drums.

Feed water is also equally divided, and ample cross-over pipes below the normal water level balance the water flow equally between the two drums. Equal steam withdrawal from both drums is ensured by taking half the steam to each of the primary superheater headers.

This simple unified system ensures that any one circulating pump will operate satisfactorily and feed both furnaces equally and simultaneously. With this arrangement, biased firing will not disturb the water levels or the steam pressure, a particular advantage during steam raising periods.

Six circulating pumps will be installed, five of which will maintain the design circulation rate at maximum continuous rating. Indeed, it is anticipated that four pumps will be adequate for the purpose.

These pumps are built integrally with the downcomer system and the design eliminates differential expansion and the consequent complication of piping. Fully automatic sequence control will be incorporated for starting the pumps in the event of failure.

The pumps themselves are of vertical spindle, single stage, centrifugal design, driven by a squirrel cage induction motor whose windings are immersed in the circulating water. The motor casing is built to withstand the full operating pressure of the system, as also are the windings, while an external cooling system is mounted locally to ensure a satisfactory temperature level.

After separation in the drums the steam passes through turbo-separators and scrubbers to the superheater, whilst the water at saturation temperature passes around the drums before returning to the circulating pumps. This ensures that the whole of the drum interior surface is maintained at a uniform temperature, a very great advantage during a quick start.

SUPERHEATERS AND REHEATERS

In line with current practice the heating surfaces of the superheater have been arranged in such a way that the maximum effective use of inexpensive carbon and low alloy steels has been obtained, thus reducing to a minimum the use of costly austenitic materials. The final stage of both the superheater and reheater is located away from the hottest zone.

In the highest gas temperature zone, platen superheaters are used consisting of a number of superheater tubes welded together to form a flat plate. The platens, spaced widely apart, are largely self-cleaning and will operate for lengthy periods without "off-load" cleaning, even when burning coals with a low ash fusion temperature.

An adequate system of cross-over tubes is incorporated in the superheater arrangement so that there is automatic compensation for any inequality of heat absorption.

Radiant superheater surface is installed in the top of the furnace; this not only permits the maximum economy of convection surface but considerably improves the steam temperature control characteristic.

STEAM TEMPERATURE CONTROL

With the advance in steam and reheat temperature the importance of close temperature control cannot be over emphasised, not only for the sake of the turbine efficiency but also to keep the metals of the boiler itself, the steam piping, the turbine blades, within safe operating limits.

Spray type desuperheaters are installed for emergency use but the primary steam temperature control is obtained by tilting burners on both the superheater and reheater furnaces. For this purpose a burner assembly is installed in each of the four corners of each subdivided furnace. One is shown diagrammatically in Fig. 2.

Each corner burner assembly consists of four coal nozzles and secondary air nozzles, arranged to discharge tangentially to an imaginary circle in the centre of the furnace to form a vortex. The nozzles can be adjusted automatically in a vertical plane between an angle of $+30°$ and $-30°$ to the horizontal, so that the flame mass is projected into any desired position within the furnace between these limits. This has the effect of varying the furnace exit temperature and consequently the superheat and the reheat temperatures. It is anticipated that constant temperature will be maintained within $\pm 10°$ F over a range of 70 per cent to 100 per cent of the maximum continuous rating. The effect of burner tilt is shown by the curve in Fig. 3.

Developed over a number of years, experience has shown that this system of steam temperature control responds rapidly to any change in operating condition, and even with the large furnace, penetration of the jets to the centre of the furnace and the resultant turbulence of the gases assures a high standard of combustion efficiency.

Progressively increased in size each of the present coal nozzles are capable of handling approximately six tons of coal per hour with an associated air quantity of 60 tons per hour.

MILLING EQUIPMENT

The mills, specially developed for the large tonnages (total coal consumption 205 tons per hour), will individually be substantially larger than any other at present in commercial operation for coal burning. Eight Lopulco three-roller mills will be installed each capable of handling over 50 tons of coal per hour, but six will normally be in operation, allowing two to act as standby for maintenance.

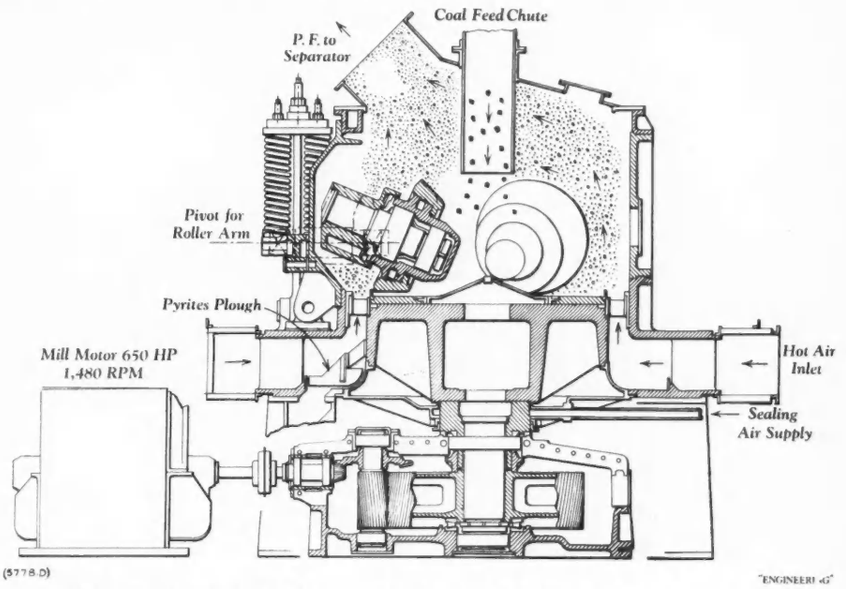


Fig. 4 Three-roller Lopulco mills are used, each having a throughput of 50 tons per hour.

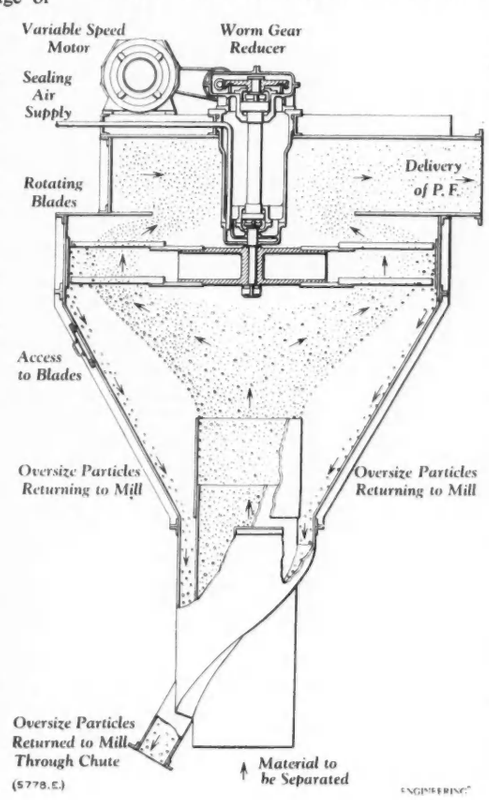


Fig. 5 From the mills, the coal panes to Double Whizzer separators; oversize particles are returned.

Each mill is capable of handling coal with a moisture content of up to 28 per cent, using hot air (obtained from the forced draught fans) at 550° F for drying the fuel. The temperature of coal and air at outlet varies from 200° F downwards according to the moisture content of the coal and the amount of recirculation of oversized material. The mill will have a centre feed enabling the outlets to be suitably positioned and thus provide a vertical straight through feed to the mill itself without bends to restrict the flow of wet and sticky coal. To achieve this the classifier has been positioned separately from the mill but near to it. The oversize, hot, dry particles from the classifier are re-delivered to the centre main feed chute, mixing with the incoming wet fuel and thus assisting both in movement down the chute and drying within the mill itself.

The fuel discharged from each mill is equally distributed to each half of the furnace and the output of each mill discharges to a single tier of burners, but the firing rate can be biased in favour of one or other of the furnaces if required.

The mill and separator designs are illustrated in Figs. 4 and 5.

Each mill is provided with a motor of 650 b.h.p., operating at 1,480 r.p.m. Lubrication of the gear box is by pump, whilst the roller arm is by drip feed at a suitably controlled pressure to assure adequate, but not excessive, lubrication. Motors for the induction fans are 1,570 h.p. and for the forced draught fans 865 h.p.

Book Reviews

CIRCUMVENTING FRICTION

Ball and Roller Bearings: Their Theory, Design and Application. By P. ESCHMANN, L. HASBARGEN and K. WEIGAND. *K. G. Heyden and Company Limited, 1 Vivian Avenue, London, N.W.4.* (56*s*)

Edited on behalf of one of the largest bearing manufacturers in Germany, this book is a translation of the German original edition. As might be expected from such an origin, there is a certain bias in the text towards the products of the sponsoring firm. This tends to restrict the field covered though it in no way affects the quality of the contents.

The book attempts in one volume to cover the whole field of ball and roller bearing engineering. The ambitiousness of this undertaking probably accounts for the considerable degree of superficiality with which the different sections of the subject are treated. In the preface it is stated that the book is intended as a guide to knowledge and its intelligent application. That intention is probably fulfilled but there is no trace of anything in the way of new knowledge. On that account, the book is unlikely to be of much value to the bearing specialist who is looking for original contributions in his field.

So far as its contents relate to practical bearing applications, the book gives very little coverage to the modern tendency to use tapered roller bearings instead of a ball and parallel roller-bearing combination. This omission leaves the impression that the book is old fashioned. In the light of modern British and American practice, most of the applications shown are reminiscent of the early 30's rather than of to-day.

On the theoretical side, the section dealing with bearing calculations is well arranged. The treatment given, however, is superficial and for a highly mathematical subject of this kind quite inadequate.

In those parts of the text which are mainly concerned with the dimensional characteristics of bearings, such as for example, in the sections dealing with tolerances and gauging procedures and fits, it is unfortunate that the English text does not contain a reference to the differences between "inch" and "metric" standards. Without such a reference, there is a danger that designers may fall into the error of attempting to apply the metric data given in cases where inch standards are required.

From the point of view of printing and layout of text, the book is extremely good. The type is clear and easy to read, and the diagrams are excellent. It is a pity that more care had not been devoted to the production of a more polished translation. The readability of the text is somewhat marred by rather pedantic English and a choice of words which is often unusual. The German idiom can also be detected on almost every page.

The notation of the original German appears to have been retained throughout the formulae in the book, and the average English reader is likely to find the use of purely German abbreviations such as "PS" rather confusing in spite of the English equivalents given in the conversion table supplied. The index is not sufficiently comprehensive for a volume of this type which is likely to be used mostly as a work of reference.

In spite of all these shortcomings, however, this book is one of the best general treatises on anti-friction bearings which have been published in the English language. It contains in one convenient volume a collection of information, principally on ball, parallel and self-aligning roller bearings as made in Germany which non-specialist engineers will find useful, and which makes it a desirable addition to the engineering shelves of any reference library.

CONVEYOR BELT EMBRACES

Automation: What it is, How it works, Who can use it. By CARL DREHER. Illustrated by HERB LEBOWITZ. *Victor Gollancz Limited, 14 Henrietta Street, Covent Garden, London, W.C.2.* (12*s* 6*d*)

In connection with the publishing of technical books, certain names spring readily to mind and Gollancz is not one of them. Any surprise that one may feel is lessened by a Goon Show type illustration on the dust cover and the listing of this title with its predecessor "How to Lie with Statistics," both books being classified as "Primers for our Time." Right, so this is presumably intended as a "Child's Guide" and as the reviewer is next door to a moron he is well qualified to assess it.

Having read the primer, the present writer is now obsessed with quite a few questions where previously he thought he had a fairly clear picture. When does mechanical handling become automation? Is automation merely a new term for conveyor-belt procedure or are they quite different? Where does remote control become automation? Is a computer inevitably automation? Of course the reviewer may have misread Dreher's message completely but the impression was there that automation is all of these and vice versa.

Apart from this confusion (and no-one else may sense it) the book gives an adequate overall picture of the growth and possible development of this new age together with its possible economic effects. Here we have a book not for the engineer but for the busy layman and for the shop steward who wants some agitation-matter. One should mention that the author is an American electronics engineer which accounts for (*a*) 1942 as the beginning of the Second World War and (*b*) an air of greater authority when he is writing on his own subject.

NEW BOOKS

Nationalisation. By E. RUBIN. *De Vero Books, 35 Buckland Crescent, London, N.W.3.* (2*s* 6*d*)

Quote: "It is the workers who are threatened, he says, and he writes in plain language so that who read may learn." 12 pages.

Newnes Engineers' Manual. By F. J. CAMM. *George Newnes Limited, Tower House, Southampton Street, Strand, London, W.C.2.* (35*s*)

A fifth edition of a well-tried favourite. BSI changes have been embodied. A comprehensive index will save a lot of time hunting through specialist handbooks and textbooks.

Electrical Who's Who 1958-59. Compiled by *Electrical Review*. Fifth Edition. *Electrical Review Publications Limited and Iliffe and Sons Limited, Dorset House, Stamford Street, London, S.E.1.* (27*s* 6*d*)

One of those volumes that are gifts to circular senders. Brief biographies of leaders in the profession and in the industry.

Mathematics for Engineers. Part 2. By W. N. ROSE. Fifth Edition Revised. *Chapman and Hall Limited, 37 Essex Street, London, W.C.2.* (25*s*)

A fifth edition of a text-book that has been a standard for years—since 1920 to be exact. Apart from chapters on spherical trigonometry and mathematical probability, this volume is devoted to the calculus.

Types of Road Surfacing and Maintenance Using Tar or Asphaltic Bitumen. Road Note No. 5 (Third Edition). Department of Scientific and Industrial Research Road Research Laboratory. *Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2.* (3*s*)

This third edition succeeds the first in 1948 and the second, two years later. A steady sale has justified a new version embodying any improvements in the past 8 years, 11 references and a list of standards complete the booklet.

Basic Electrical Engineering. By J. SHEPHERD, A. H. MORTON and L. F. SPENCE. *Sir Isaac Pitman and Sons Limited, Pitman House, Parker Street, Kingsway, London, W.C.2.* (27*s* 6*d*)

Aimed at the London University degree course, Part I, in electrical engineering, and the intermediate City and Guilds. MKS notation is used throughout. Worked examples are included in the text.

The Influence of Aluminium, Lead and Iron on the Structure and Properties of Galvanized Coatings. By J. J. SEBISTY and J. O. EDWARDS. Mines Branch Report R 5. *Department of Mines and Technical Surveys, Ottawa, Canada.* (25 *cents*)

A Study of Surface Carbides, Differential Steel Attack and Pore Formation in the Galvanizing Process. By J. J. SEBISTY. Mines Branch Report R6. *Department of Mines and Technical Surveys, Ottawa, Canada.* (25 *cents*)

Reports issued by a committee formed to develop new and improved zinc products, with all that this involves.

Table of Natural Logarithms for Arguments Between Five and Ten to Sixteen Decimal Places. National Bureau of Standards Applied Mathematics Series 53. *Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.* ($4.00)

A re-issue of Volume IV of the Mathematical Tables Project of the FWA in 1941 (Mathematical Table No. 12). Can be obtained through HMSO.

Functions of Real Variables and Functions of a Complex Variable. By WILLIAM FOGG OSGOOD. *Chelsea Publishing Company, 50. E. Fordham Road, New York 68, N.Y., USA.* ($4·95)

One looks in vain for a publication date of this book but the author's preface is dated 1935. The author is professor of mathematics at Peking University.

Adressbuch der Giesserei-Industrie in der Bundesrepublik Deutschland. *Giesserei-Verlag G.m.b.H. Postfach 2590, Breite Strasse 27, Düsseldorf, Germany.* (20 *DM*)

20 DM seems a lot of money to spend on what is, after all, a trade directory. It does, however, embody almost everything one would wish to know about any particular firm or its products.

Ausbeulen: Theorie und Berechnung von Blechen. By CURT F. KOLLBRUNNER and MARTIN MEISTER. *Springer-Verlag, Reichpietschufer 20, Berlin, W.35, Germany.* (42 *DM*)

Deals with strength of materials applied to plates, stressed skin, etc. About 4 guineas in this country. The 344 pages are divided into seven sections, a bibliography, and a name index.

MILLS OF KRAMATORSK

Rolling Mills: Design and Calculations. By A. A. KOROLYOV. *Gosudarstvennoe Nauchno-Teknichesko Izdat. Mashinostroitelnoi Literatury, Moscow.*

This book describes contemporary design of rolling mills and mill ancillary equipment. Old type mills such as the 3-high Lauth and the hot pilger mill are not included. In some relatively small fields (e.g. planetary mills) where Russian data are lacking, foreign experience is quoted. Brief reviews are included of wheel and tyre mills and tube mills. The properties of cast irons, steels and light metals used for rolling mill parts are described.

Beginning with a fundamental classification of rolling mill types, the author examines the basic concepts of hot and cold working, the theory of rolling including the interesting question of pressure distribution in the arc of contact. The book includes detailed chapters on roll design, materials for rolls, mill bearings, electric drives, screwdown and roll adjusting gear, guides and roll changing devices, spindles and couplings. Some typical rolling mill calculation problems are provided and some useful data on calculating the optimum power of electric drives.

Many of the data used are taken from actual experience with new Russian mills and from designs associated with projected installations. The descriptions of new Russian mills are based on data supplied by the Urals Heavy Engineering Works (UZTM), the Novo Kramatorsk Engineering Works (NKMZ), the Stary Kramatorsk Engineering Works (SKMZ) and the central design office of Metallurgical Engineering (TsKBMM), Gipromez Stal'proyekt, etc.

Since the war there has been a lack of detailed British text books on specific fields of production in the iron and steel industry, as compared with the output of general text books covering the entire field of iron and steel production or of books on the theoretical side. The Russians are meantime publishing some excellent books on quite distinctly limited fields of production. Korolyov's book is a first-class example, carefully and logically planned. It is well worth having in the reference library of any British and American steelworks.

The book has a single drawback which it shares with all other Russian text books in that it has no final index for quick reference. In spite of this, the entire field with which it deals is so systematically divided that it is comparatively easy to seek the point one requires.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Pushing Cylinders for Underground Conveyors and Loaders. NATIONAL COAL BOARD, Hobart House, Grosvenor Place, London, S.W.1. Information Bulletin No. 58/199. Increased use of power loaders and armoured flexible conveyors in mining has extended the use of pushing cylinders. Originally all cylinders were compressed air operated, but the present trend is towards the adoption of the hydraulic type, which offers several advantages. Nevertheless, many compressed air cylinders are still used in British collieries, and the Bulletin deals with both types.

Electric Shotfiring. IMPERIAL CHEMICAL INDUSTRIES LIMITED, Nobel House, 25 Bothwell Street, Glasgow, C.2. Several different detonators are described and illustrated in this brochure, together with a range of exploders. The second part of the brochure deals with the use of the equipment, and describes single and multi-shot firing, the use of mains firing circuits, and the testing of circuits and exploders. An appendix provides detailed information on safety precautions, to prevent accidental firing.

Electronics

Terminal Blocks. PRECISION COMPONENTS (BARNET) LIMITED, 13 Byng Road, Barnet, Herts. "Kabi" unit terminal blocks, type U30 rated at 30A and moulded in blocks of four, and U60 in single units and rated at 60A. With or without covers. Leaflet.

Clip-On Ammeter. FERRANTI LIMITED, Hollinwood, Lancs. Pole-mounted clip-on ammeter for use on overhead lines, up to 11 kV. Five ranges from 0 to 200A with accuracy within 3 per cent of full scale on all. Normally calibrated for 50 cycle supplies. Leaflet In.17P.

Portable Ammeters. RECORD ELECTRICAL COMPANY LIMITED, Broadheath, Altrincham, Cheshire. Industrial type portable ammeters and voltmeters. Leaflet.

Electricity in Agriculture. BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION, 2 Savoy Hill, London, W.C.2. Booklet "How E.D.A. Helps You and British Agriculture" lists literature dealing with such items as poultry, dairies, pigs and soil warming, as well as models and film strips.

Instruments. SOLARTRON ELECTRONIC GROUP LIMITED, Thames Ditton, Surrey. The Short Form Catalogue describes briefly oscilloscopes, amplifiers, power packs and other instruments made by the company.

Motor Control Relay. RADIOVISOR PARENT LIMITED, Stanhope Works, High Path, London, S.W.19. "Motoload" relay gives warning of any increase in current drawn and performs a warning, or switching action. Leaflet.

Valves and Semiconductors. MULLARD LIMITED, Mullard House, Torrington Place, London, W.C.1. Valves, tubes, and semiconductor devices for communications and industrial applications, with lists of their CV and American equivalents. Catalogue.

Feed Controller. STANDARD TELEPHONES AND CABLES LIMITED, 10 Essex Street, Strand, London, W.C.2. Acoustic mill-feed controller for the automatic operation of grinding mills using the noise level of the process. Illustrated brochure.

Valve Rectifiers. MULLARD LIMITED, Mullard House, Torrington Place, London, W.C.1. Mercury and xenon valve rectifiers for power supplies. Up to 75 A peak. Characteristics and circuits given in leaflet.

Synchros and Servos. MUIRHEAD AND COMPANY, Limited Beckenham, Kent. Synchro resolvers, transmitters, transformers and receivers for most applications. Two-phase servo motors and tachogenerators. List of types.

Miniature Relays. LONDEX LIMITED, Anerley Works, 207 Anerley Road, London, S.E.20. Miniature industrial relays, spring contacts, mercury or micro-switch operation, open or plug-in totally enclosed types. List No. 178.

Electrical Actuators. THE PLESSEY COMPANY LIMITED, Ilford, Essex. Electrical (motor driven) actuators for both linear and rotary movements. Twenty-six models with powers up to 2,500 lb (linear), or 750 lb-in (rotary). Also reduction gearboxes and end fittings. Seventy-page catalogue gives dimensions, circuits and operation curves.

On the Shelf

By Frank H. Smith

The Manchester Public Libraries must be well heated. The cover of their 106th Annual Report bears a delightful study entitled "The Reading Girl" and there she is, seated (presumably on marble) with no shoes or stockings and little more than the lounge curtain draped over her right shoulder. As a matter of fact she is by Ciniselli and the statue stands on the staircase in the Central Library. As usual with libraries, everything is "up," stock, loans, costs—the lot. I suggest that local authorities who are interested should write for a copy to the Central Library, St. Peter's Square, Manchester 2. The final sentence is worth quoting: "There was a net profit on the year's operations of £1,606." That refers to the Library Theatre, and those writers to *The Times* on theatre losses and should they be subsidised might well take note.

The *Unesco Monthly Bulletin on Scientific Documentation, etc.* for October contains the news that its editor (since the first number in May 1952) is age-retiring. He is Dr. J. Edwin Holmstrom and I have known him (though he does not know me very well) for over 20 years. He was originally trained as a civil engineer but shortly before the war he decided that documentation was his *forte* and he is now one of the acknowledged leaders in that field. We, in the Civils library, used to be partly impressed, partly amused and partly overawed by the way he would come along to ask for a reference and pull a small filing system of 5 × 3 cards out of his pocket with all relevant details on them. If my memory serves me aright, he left civil engineering to take a post with ICI where he set up a central department for the filing of all technical information. This included not only journals, reports and books but also anything that might be contained in correspondence.

The *Unesco Monthly Bulletin on Scientific Documentation, etc.* for October also announces a bibliographical survey by a Mr. R. C. Benge on "Technical Education in the United Kingdom." The price is 3*s* 6*d* and I think HMSO can oblige. The same number of the Bulletin mentions a book published by Stanford University Press called "The Soviet Academy of Sciences," by A. Vucinich. It may surprise you to know that this Academy is 225 years old, but some of the figures that the Bulletin quotes from the book (e.g. a personnel of 20,100 persons) will surprise you more. Of course personnel may be just another word for membership. Anyway, the book costs only $2 so why not buy it and astonish your friends? Oxford University Press are agents in this country and they will charge you a mere 16*s*.

The *Unesco Bulletin for Libraries* for October (HMSO, 1*s* 8*d*) carries an informative and interesting article by the official in charge of the International Lending Service at the Library of the USSR Academy of Sciences, Leningrad. The title is "International Library Loans: problems encountered at the Library of the USSR Academy of Sciences." It may come as a shock to many people to realise that not only are the USSR prepared to co-operate, they are *anxious* to do so.

Readers may judge what an unsophisticated ingenuous little thing I am by the frequency and ease with which I am astonished. For instance, I am astonished that the foremost scientific library in the country (the Science Museum Library, no less) has no microcard reader.

Lest anybody think that young gentlemen go to to the City and Guilds College of the Imperial College of Science and Technology to laze let him consult "Research Report 1955-58." The five departments (aeronautics, chemical engineering, civil engineering, electrical engineering and mechanical engineering) are reported on separately, and the report as a whole is a remarkable reflection of modern techniques.

Production

EPICYCLIC GEARS FOR MANY PURPOSES

A notable trend in power transmission since the war has been the increased use of epicyclic gears. To meet the growing demand for epicyclic gear units, the old-established engineering organisation of W. H. Allen Sons and Company Limited have, since 1955, been reorganising their gear production facilities, which are now located at the Atlas Works, Pershore (Fig. 1), reopened recently by Admiral Sir William Tennant, K.C.B., C.B.E., M.V.O., Lord Lieutenant of Worcestershire.

For many years the firm have manufactured speed-reducing gears of the parallel-shaft type, mostly as components of the company's wide range of products which include steam turbines, gas turbines, diesel engines, steam engines, pumps, fans, and electric motor control gear. The manufacture of epicyclic gears was the result of a licence and design consultancy agreement with Herr Dipl.-Ing. W. Stoeckicht of Munich, with whom the company has worked in close co-operation in the further development of epicyclic gearing for many power transmission requirements.

Formerly, epicyclic gears were of the spur or single-helical type, but recently the double-helical epicyclic gear train has gained much ground. In 1951 there were only a few in use but by 1958 there were around 1,500 applications transmitting a total of 3 million h.p. Individually the horse-powers transmitted range from 100 to over 10,000 and the gears provide a very wide range of speeds up to 45,000 r.p.m.

The main advantages of epicyclic gears are the considerable savings in weight and space as compared with parallel-shaft gears. A cut-away drawing is shown in Fig. 2 of the assembly of component parts of a typical Allen-Stoeckicht patented double-helical epicyclic gear unit. The transmitted load is shared between several tooth contacts by providing an annulus system which itself is flexible and connected to the gear case shaft by means of a double gear-tooth-type flexible coupling. In addition, in high-speed applications, the central sun wheel, which is supported by the planet wheels and has no bearings, is connected to the high-speed shaft by means of a double tooth-type coupling.

Typical of the many gear units specially designed to meet individual requirements is a 160 h.p. two-speed epicyclic gear for transmitting a maximum torque of 110,000 lb-ft at a minimum speed of only 9 r.p.m. (Fig. 3). This gearbox is for a new type of mine tunnelling machine driven by a two-speed motor, with input speeds of 1,500 or 650 r.p.m. The gear incorporates a two-speed unit and a double-reduction unit to provide four output speeds, 24 or 18 r.p.m., 12 or 9 r.p.m., with an overall ratio of just over 80 : 1. The largest annulus is 30 in dia. and the unit is only 6 ft in length and weighs 5½ tons. For mine tunnelling machines the factors of space, weight and reliability are of prime importance; four similar gear units are being used for these machines.

An advance design to cope with higher horse-powers is an Allen-Stoeckicht double-helical planetary epicycle gear for a motor-driven mine hoist. The gear unit is capable of transmitting 3,200 h.p. continuously with a speed reduction from 486 to 64 r.p.m. Two of these units used as drum winders have been in service for the last two years on mine shaft sinking duty at the Monktonhall Colliery of the National Coal Board (Fig. 4), but eventually they will be used as a multi-rope tower-mounted friction winder. In this case the annulus diameter is 43 in but the

Fig. 1 General view of the gear cutting shop at the Atlas Works of W. H. Allen Sons and Company Limited, Pershore.

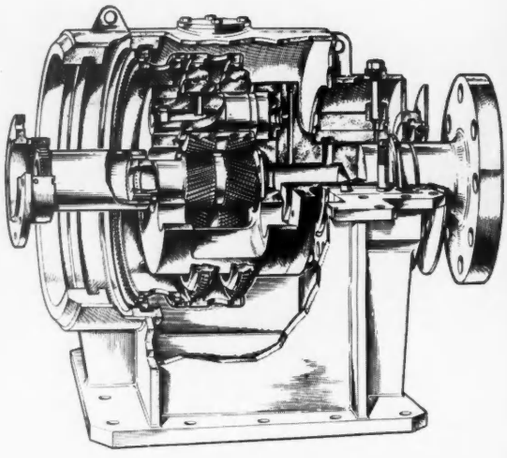
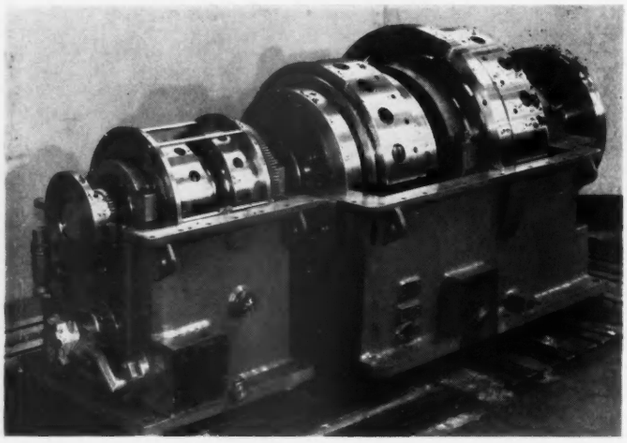


Fig. 2 Cut-away drawing of a typical Allen-Stoeckicht double-helical epicyclic gear unit.

Fig. 3 Epicyclic gearing for a 160 h.p. mine tunnelling machine. A two-speed and a double-reduction unit are incorporated to provide output speeds of 24 or 18, 12 or 9 r.p.m. from a two-speed motor running at 1,500 or 650 r.p.m.



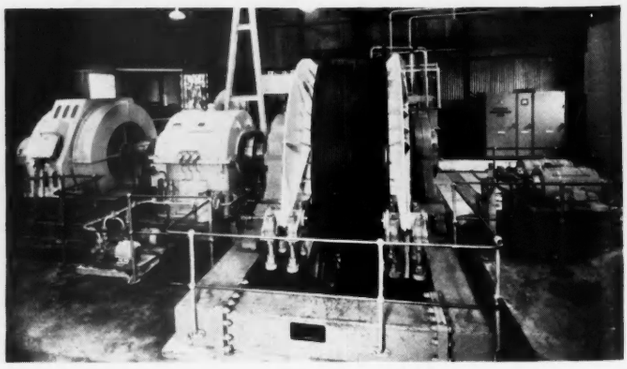


Fig. 4 Motor-driven drum winder with double-helical planetary epicyclic gear being used for sinking the mine shaft at the Monktonhall Colliery of the National Coal Board.

FLUTED CORE RADOMES FOR BRITANNIAS

One of the new "fluted core" Britannia radomes in a production shop. The line of fluting can be seen in the radome structure.

Glass fibre radomes, manufactured by the "fluted core" process developed by Bristol Aircraft Limited, Bristol, will be fitted to the four long-range Britannias soon to be delivered to Compania Cubana de Aviacion. The cloud collision warning radars for these aircraft differ from those at present in service with Britannias, which use the X Band frequency. The Cubana equipment will operate on the C Band frequency, in general use in the USA. The "fluted core" construction consists basically of two outer walls moulded integrally with intermediate corrugations or cells.

The sandwich is made up by laying glass in the mould and packing flexible wax mandrels or formers, wound with glass cloth tape, between the separate surfaces of the two skins. After the resin is injected—it can be either cold or hot setting—the tool is opened and the moulding removed to an oven for the post-curing of the laminate and the melting out of the wax mandrels.

For the radome, the outer skin of glass cloth is laid up in the female half of the mould, and the inner skin laid up on the male mould which is then located into position. Clamping bolts lock the halves together and resin is injected under pressure from the bottom of the mould. The radome is made up with a cold setting resin and therefore allowed to cure in the tool before post-cure treatment in an oven.

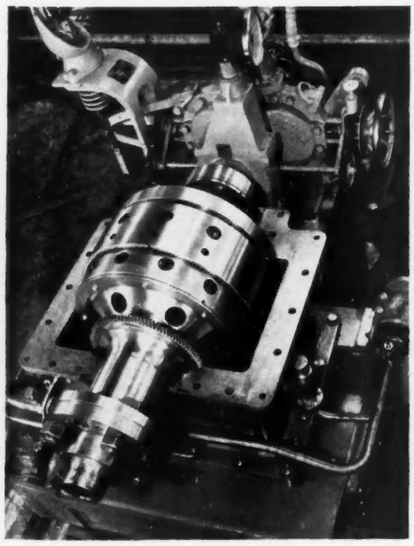
This method of construction holds certain advantages over earlier construction processes. In the first place, fluted core radomes can be produced at considerably less cost. The tooling is fabricated in glass laminate, avoiding the need for expensive machining operations and, as the whole manufacturing cycle is relatively simple, the number of skilled man-hours required to complete the job has been reduced to a minimum. Moreover, as the radomes are moulded integrally they are stronger than "built up" structures, have higher resistance to impact damage, and able to be consistently moulded to finer limits of dimensional accuracy.

Concluding Epicyclic Gears

complete gear still weighs only 9 tons.

An epicyclic speed-increasing gear for a 2,400 h.p. motor-driven boiler feed pump assembled for testing is shown in Fig. 5. The motor speed of 1,500 r.p.m. is increased to the pump speed of 4,500 r.p.m. This gear has no main bearings, the rotating annulus assembly, which forms the low-speed shaft, being connected direct to the motor shaft. The high-speed sun wheel is supported between the three planet wheels and is coupled direct to the pump shaft through a gear-tooth-type flexible coupling. This arrangement eliminates the use of external flexible couplings and gives a very compact and highly efficient gear for the duty. An interesting development was the white-metal facing of the planet wheel spindles which was claimed to provide for more uniform spread of the bearing loads than could be obtained by the use of bushes. Gear units of this type are being manufactured for compressor and blower drives. One is for an 11,000 h.p. motor-driven centrifugal compressor to be installed in Canada; in this case the gear internals are so designed that they will be mounted in the pedestal supporting the motor/compressor bearings.

Fig. 5 Speed-increasing epicyclic gear for 2,400 h.p. motor-driven boiler feed pump, assembled for testing.



A reverse reduction gearbox has been specially designed for the Admiralty for the fast patrol boats of the Brave Class. These boats (ENGRG. 10 Jan. 1958, p. 63) are powered with Proteus gas turbines providing a maximum rating of 3,500 s.h.p. The gearbox transmits full power ahead or astern, no clutches are used and reversing is achieved by a hydraulically-operated brake; incorporated are a hardened and ground V-drive and parallel-shaft transfer gear, in addition to the epicyclic reversing reduction unit.

PRODUCTION FACILITIES

The Atlas Works, Pershore, are equipped with the most up-to-date precision machinery for gear production, both for epicyclic and for high-quality parallel-shaft turbine gearing.

Most of the gear-cutting machines have been transferred from the Queens Works, Bedford, and include precision gear-hobbing machines, gear shapers, gear grinders and shaving machines. A 72 in David Brown-Muir machine and two Sykes 3C gear generators have been installed; the latter have been specially built to produce epicyclic gear sun and planet wheels (in which both helices may be cut simultaneously) to close tolerances, and also for the production of internal gear rings. In the gear cutting shop is also a No. 7 Société Genevoise jig-boring machine which is used for precision work such as the holes in the planet carriers for planet wheel spindles. The machine shop for general-purpose machining is well equipped and includes large horizontal borers and a 100 in Lumsden surface grinder. The latter machine is used to finish the joint faces of all gear cases without the need for filing and scraping operations. There are also two electro-magnetic Avery dynamic balancing machines, capable of balancing components weighing up to 6,000 lb.

For inspection purposes two Maag PH.60 measuring machines and two Goulder gear checking machines are used. An electric annealing furnace is used for stress-relieving components between machining operations. In the heat-treatment shop are also installed the nitriding plant which is used for the surface hardening of most epicyclic gears and facilities for white metal facing of bearings and planet-wheel spindles. Most of the hardened components are shaved before nitriding to sufficiently close tolerances, but in some cases, components which have been case hardened are subsequently ground on Maag machines. Crack detection equipment is used for the inspection of all hardened components.

MAKING CAR ACCESSORIES

Serck Radiators Limited and Armstrong Shock Absorbers Limited have ended their year on a note of triumph which fully reflects the motor car boom. Mr. W. H. Newton, chairman of Serck, reports a trading profit (year ended 2 August) of £1·5 million, compared with £1·2 million the previous year, and comments that the current financial year was started "with a satisfactory order book, reasonably well spread over our products and over the industries we serve." This, of course, includes the products of the Audley Engineering Company (Audco), and Serck Tubes, such as valves, control equipment, machine tools, plant for the chemical and oil industries, etc. The company rely extensively on their research and development department "to bring forward improvements which gradually lead us into new fields." One of the new products recently developed (in conjunction with Ferranti) is an electronic programme-controlled drilling machine, with multi-spindles, the initial results of which, said Mr. Newton, "encourage us to believe that it will prove an important development."

Armstrong Shock Absorbers are more dependent on automobile industry activity than Serck, and have therefore benefited from the boom to an even greater extent. Their chairman and managing director, Mr. William Armstrong, announced a group profit of £233,000, compared with £124,000 the previous year (ended 30 June). Despite the present most favourable operating conditions—with every prospect that they will continue far into the current financial year—ASA have gone ahead with a programme of diversification announced last year, albeit on a small scale. Their Heli-Coil division has expanded substantially and the door-closer and the hydraulic remote control, both adaptations of the shock-absorber hydraulic cylinder which was put on the market last year, are developing well.

Marketing

Selling By Distributors

The need for improved salesmanship was the talk of the assembly at the annual meeting of the Association of Engineering Distributors held in London recently. Before the luncheon, Mr. R. F. Collinshon of the Incorporated Sales Managers' Association, spoke on "The Art of Selling." After lunch, the Master Cutler of Sheffield, Mr. J. Hugh Neill, made two important qualifications to the view that "the engineering distributor is of real value to both manufacturers and consumers." First that they should not be the only channel through which the lines they handle can be sold and second that the engineering distributor is by no means indispensable to every manufacturer. "There may well be," said Mr. Neill, "a limit to the volume of sales which can be achieved without the services of the engineering distributor. Those services, however, do not, in themselves, guarantee any particular volume of sales and, therefore, in the case of lines where certain brands predominate, the manufacturers of other brands may well find it possible to achieve a bigger volume of sales by selling through some other channel, or by going direct to the consumer, than they could achieve by entrusting the distribution of their products to the engineering distributor."

The whole of the Master Cutler's speech was concerned with the distribution problems of the tool trade. There is no such thing, he said, as a distributor's right to a particular discount. The amount should be fixed by negotiation and should be related to the value of the services performed by the distributor. He warned against price cutting—the maintenance of prices is essential to the trade's survival, whether the manufacturer's price is a common price agreed by the industry or his own. Clearly Mr. Neill and many of his colleagues take most seriously the AED's effectiveness, which affects the tool industry so vitally. Considerable goodwill exists, and some very long standing associations between manufacturer and distributor. Nonetheless, there is a need for an all-round improvement of sales methods, and Mr. Collinshon's talk, the *a b c* of selling in general terms, given at the AED'S request, was in itself evidence that they are well aware of this problem.

Best for Exports

The problems experienced by engineering firms who have attempted to increase their export turnover are familiar enough. They are primarily problems of finance—expenditure is high and returns are slow—and problems of remoteness. In most cases little control can be exercised over agents due to inadequate market information, or to the inability of the exporter's executives to visit agents and customers often enough.

In other words, it is difficult to export successfully unless one's products are of world repute and can therefore be sold through established merchanting channels or unless the company concerned are large enough to have adequate staff to direct and supervise overseas agents or representatives. It was the conclusion that "although there are plenty of official bodies and associations willing to give the smaller manufacturer advice concerning exports, there is a lack of organisations which are prepared to go further than this and do the actual exporting for a company" which led Mr. S. J. Best to set up as "an independent export manager offering a complete export service."

Mr. Best considers that there are many small and medium-size firms whose export potential would not warrant the setting up of an export department headed by a competent export manager. By becoming the export manager of several small to medium-size companies, Mr. Best is confident that he can do a good job of exporting for each of them and that the cost to each will be relatively very small "When I take on the overseas sales of a company," he states, "I undertake to do everything that is necessary to export that company's products. This includes finding and appointing suitable agents abroad, visiting foreign countries when necessary, dealing with export correspondence, supervising orders, and looking after shipment and documentation. I am rewarded in two ways: first by a small nominal retainer which lasts for the first two years only and is intended partly as earnest money and partly to recover a small proportion of my expenses in setting up overseas outlets, and secondly by a small commission on sales made abroad. The amounts concerned vary in relation to the size of the company and its export potential."

This type of service has been available to industry for a good many years but generally it has been either on a market or on an industry basis. Enterprising salesmen have set themselves up as exporters to Latin America, or Eastern Europe or to a single large market. Their method has normally consisted in living on the spot—a convenient base in their area of operations—and in making frequent visits to this country. They are the "modern" agents, and have tended to tackle the more difficult or remote markets which firms have been reluctant to enter unaided. The good ones have set up an organisation but sooner or later they have had too many products to sell and lost much of their effectiveness. Some industries have grouped themselves to sell on a co-operative basis—in a few cases very successfully.

There is room for S. J. Best, but his success must depend on the quality of his organisation and on his own ability to limit his activities to a manageable number of companies and products.

Cummin's Challenge

An encouraging view of the prospects of the diesel engine manufacturing industry was put forward recently by the President of Cummins Engine Company, Inc., Mr. R. E. Huthsteiner. Cummins, who make part of their range in Britain, anticipate that their sales will double, to approximately $200 million, by 1962. For over five years now they have held over half the truck diesel market in the United States and are extending their operations overseas. Mr. Huthsteiner stated that Cummins would continue to "force the pace" in the diesel industry by (*a*) developing higher output, lighter weight, more compact engines, (*b*) reducing costs of product, of its operation and of maintenance, (*c*) concentrating on limited and difficult power problems rather than diversifying and (*d*) developing new and more advantageous forms of power.

Cummins have done much better in Britain than most of their rivals expected. They operate according to "a carefully prepared forecast, regularly brought up to date, covering a period of 5 to 10 years" and are now intensifying their efforts to establish the Cummins name by undertaking "a more substantial programme of world-wide advertising, product, trade mark and service point identification than is customary in the diesel industry."

Further Price Falls

Prices continue to fall, particularly for electrical machines and equipment. Lancashire Dynamo have reduced their prices for motors in the British Standard totally enclosed "Fankuld" range and ventilated types up to 50 b.h.p. (as from 1 November). English Electric have done likewise for their class LY and Class C ranges of squirrel-cage motors. The price level of standard electrical motors has fallen substantially over the past year.

GEC announce the abolition of extra charges for all Osram tubes for switchless start circuits, which will means 1*s* less for metal striped tubes and 6*d* on silicone-treated tubes. This was made possible by a new low-cost process for the application of a hard wearing external metal conducting strip to the exterior surface of fluorescent tubes.

Oil Burners on Credit

The practice of offering hire purchase terms to their customers is growing among manufacturers of engineering products, and particularly those sold direct to the public or to small firms. Manufacturers of agricultural machinery, such as Massey-Ferguson and David Brown, have done so for a considerable time at the best terms obtainable from hire purchase companies. Now another concern is following suit, in the capital as well as the consumer goods field.

White's of Hebburn, who manufacture a range of oil burners—Firepak, Firejet and Spinfire—for domestic and industrial use—have just instituted hire purchase facilities. Their scheme is simpler than most, and dealings are entirely with the company. A deposit of 20 per cent is payable on acceptance of order, and the balance by monthly instalments over 12, 18, 24 or 36 months. On a burner costing £1,000, charges total £52 on a 12 months scheme, rising to £155 19*s* 0*d* on a 36 months' scheme, inclusive of all charges, including insurance.

Britain is fast moving into a consumer credit era similar to that in the USA which followed the war. The volume of hire purchase will certainly increase and the cost of it may fall further. It could provide a considerable stimulus to sales, particularly of domestic equipment such as oil burners, boilers, central heating and other basic household equipment.

Vive Le Sport

Britain seems to be known in the deep South (Texas, USA) mainly for sporting guns, sports cars, her distant past and the Old Vic Company. The slant on history is particularly emphasised with paintings, prints, sculpture, books and historical costumes being singled out—not to forget pipes. It may not of course be a bad thing to have acquired the reputation of a cultured fairly superior if somewhat elderly spiritual mother with one or two offspring such as XK150's, MG's and DB4s, or the latest fashion or even Thomas Moore.

All this and much besides was on view at Dallas last month, when the chief British delegate to the United Nations, Sir Pierson Dixon, opened a "British Fortnight" at a ceremony at Neiman-Marcus, the city's exclusive department store. Apart from the chimes of Big Ben (as a background noise, three times each day), there was Henry V, Twelfth Night and Hamlet.

Operation and Maintenance

ANALYSING IMPACT NOISE

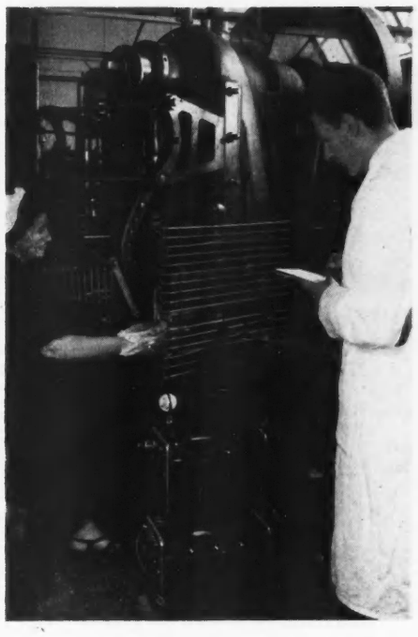
The noise made by power presses, pneumatic hammers and similar equipment is extremely annoying and, according to recent research, potentially the most dangerous to hearing. Unfortunately, the short duration of individual impacts makes it difficult to measure such noises accurately, except with laboratory techniques involving the use of an oscillograph and camera.

A more practical method of measuring impact noise in the workshop is offered by the introduction of the type 1412 impact noise analyser by Dawe Instruments Limited, 99 Uxbridge Road, London, W.5. The instrument, a prototype of which was first shown at the last Physical Society Exhibition, has now been developed to the production stage. Complete with self-contained batteries, the production model weighs 8½ lb; it provides three rectifier circuits feeding low-leakage capacitors, which store up electrical charges representative of the different parameters of the noise until these charges can be displayed for a sufficiently long period to enable a reading to be taken.

The first, or " peak " circuit, has an extremely short response time so that the magnitude of the most transient noise encountered in industry can be accurately determined by measuring the charge on the capacitor. The duration of the impact is established by noting the amount by which the charge of the " time-average " circuit —which has a relatively slow and adjustable response time—falls below that of the " peak " circuit. The third, or " quasi-peak " circuit, combines a fast response time with a decay time of about 0·6 sec, which enables it to measure the magnitude of impact noises repeated too rapidly for readings to be taken with the " peak " circuit between successive impacts.

Such intermittent noises as those emitted by pile drivers, drop stamps and the explosive hammers used for driving studs into concrete are measured with the " peak " circuit, while the " quasi-peak " circuit is used for rapidly repetitive noises such as those made by punch presses or road drills. The latter circuit also provides a convenient way of calibrating the analyser with reference to a sine wave input.

With a suitable accelerometer the analyser can also be used to measure peak acceleration or to analyse any impulsive waveform from an electrical source capable of supplying 1 volt peak across 50 kilohms. If detailed knowledge is required of the frequency composition of the input, an octave band analyser can be employed to assess the characteristics of the impulse in terms of octave bands.



A Dawe impact noise analyser (lower instrument) plugged into a sound level meter for investigation of power press noise.

PRIZES FOR IDEAS

Plant, labour and materials must be used efficiently, but at the same time the consumer expects a choice of products. These two concepts are in many respects in conflict, yet there is no denying the truth of both. How to reconcile the two is one of the most important of the many problems of management. From a production point of view the greater the degree of simplification, standardisation and specialisation in the works, the better, but this must be achieved with due consideration for consumer choice. Variety reduction, a term used by the British Productivity Council to cover the whole field of internal simplification, offers much scope for ideas, and to encourage thought on this subject a prize essay competition has been organised by the Council.

The competition is divided into two categories, an open competition with a prize of up to 150 guineas, and a student competition with a prize of 15 guineas. Additional prizes may be awarded in either category at the discretion of the Council. There are a few simple rules to be observed in both categories; particulars are obtainable from the British Productivity Council, 21 Tothill Street, London, S.W.1.

DURABLE JOINTLESS FLOORING *for Vehicles*

A method of producing an inexpensive and durable jointless floor covering for commercial vehicles has been perfected by Tom Byatt (Engineers) Limited, Fenton, Stoke-on-Trent. Based on polyester resin made by Bakelite Limited, the new flooring surface is designed to protect the original floor against injury and will successfully withstand the damaging effects of heavy and abrasive materials such as coal, coke and granite.

The method of construction adopted is to score the original floor of the vehicle to provide a suitable key. A layer of Bakelite polyester resin suitably modified with an abrasive grit is then spread in a continuous film over the surface. A 2 oz glass-fibre mat impregnated with a similar mix is then fixed into position over this first coat and the operation completed by the application of a final layer of the same resin containing a high proportion of grit. The covering is then consolidated by rolling and allowed to set.

With the exception of materials likely to destroy the surface by burning (for example, hot ashes) any load can be accommodated on the Byatt flooring. Being waterproof, it is particularly valuable for carrying " wet loads " such as sand and gravel and the floor can, in fact, be washed down after each load without danger of deterioration. Repairs, where necessary, are easily effected merely by building up the damaged section.

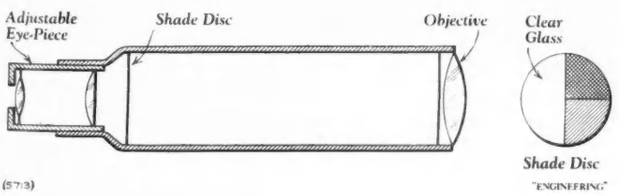
Proving tests on the new floor surface have included shock loads of 2 cwt granite blocks dropped from a height of 3 ft and, under service conditions, 10 to 12 short hauls per day, carrying loads of granite, rock and ore are being successfully accomplished without undue wear.

With no loose edges to impede free passage of contents, the new floor has proved particularly effective on all types of tipping vehicles and the weight of an average reinforced resin lining for a 6 ton long wheel base lorry is only 36 lb compared with 1½ cwt for a conventional steel floor lining.

ESTIMATING SMOKE DENSITY

Emission of dark smoke from a chimney stack, always undesirable from a fuel economy point of view, now has a legal as well as an economic aspect; it is an offence under the Clean Air Act. Estimation of smoke density by the accepted standard of measurement, the Ringelmann chart, is an unwieldy operation, requiring two observers, one to hold the chart while the other lines it up visually with the top of the chimney. There is therefore a need for a simple device which will enable the density of smoke to be estimated quickly and easily.

Such a device, the " Telesmoke," has been designed by the Department of Scientific and Industrial Research, Charles House, 5/11 Regent Street, London, S.W.1. It consists of a small low-powered telescope, having inside the body a glass disc with one half clear and the other half divided into two translucent shades. These shaded portions are of such densities that they correspond to shades 2 and 3 on the Ringelmann chart. To use the instrument it is focused on the smoke and an inverted image is obtained in the clear half of the glass disc. This is then compared with the two shaded portions, the results being, it is claimed, at least as accurate as when using the Ringelmann chart.



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Quick and easy estimation of smoke density possible with the DSIR " Telesmoke."

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Brains Trust on "Education, Training and Status of Electrical Technicians." Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Mon., 1 Dec., 6.30 p.m.*

British Institution of Radio Engineers

MANCHESTER
"High Input Impedance Direct-Current Amplifiers," by S. Stuart. North Western Section. College of Technology, Sackville Street, Manchester 1. Thurs., 4 Dec., 6.30 p.m.

British Interplanetary Society

LONDON
"Rocket Nozzles and Exhaust Jets," by E. T. B. Smith. Caxton Hall, off Victoria Street, S.W.1. Sat., 6 Dec., 6 p.m.

Chemical Engineering Group

BRISTOL
"Titanium and Its Alloys as Materials of Construction for Chemical Plant," by Dr. K. W. J. Bowen. Chemical Department, University of Bristol, Woodland Road, Bristol. Thurs., 4 Dec., 6 p.m.

Chemical Society

LEICESTER
"Stereochemistry and the Transition Metals," by Professor R. S. Nyholm. Nottingham and Leicester Branch. The University, Leicester. Mon., 1 Dec., 4.30 p.m.

Combustion Engineering Association

LEEDS
Brains Trust on "Utilisation of Low-Grade Fuels." Northern Region. Hotel Metropole, Leeds. Thurs., 4 Dec., 2.30 p.m.

Illuminating Engineering Society

CARDIFF
"Industrial Lighting Problems," by W. Imrie-Smith. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., 4 Dec., 6 p.m.
EDINBURGH
"Glassware for Lighting Fittings," by D. Shellshear and C. D. Cartwright. Edinburgh Centre. YMCA, 14 South St. Andrew Street, Edinburgh. Wed., 3 Dec., 6.30 p.m.
GLASGOW
"Glassware for Lighting Fittings," by D. Shellshear and C. D. Cartwright. Glasgow Centre. British Lighting Council, 29 St. Vincent Place, Glasgow, C.1. Thurs., 4 Dec., 6.30 p.m.
HULL
"Photo-Electric Cells and Their Applications," by F. A. Benson. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Mon., 1 Dec., 6.30 p.m.
NOTTINGHAM
"Lighting—and Other Things—in Moscow and Leningrad," by A. G. Penny. Nottingham Centre. Electricity Service Centre, Nottingham. Thurs., 4 Dec., 6 p.m.

Incorporated Plant Engineers

LONDON
"Historical Development of Electric Traction," by E. Openshaw Taylor. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Tues., 2 Dec., 7 p.m.*
PETERBOROUGH
"Road Construction," by J. M. Fisher. Peterborough Branch. White Lion Hotel, Church Street, Peterborough. Tues., 2 Dec., 7.30 p.m.
SOUTHSEA
"Safety in the Use of Electricity," by S. J. Emerson. Southern Branch. Royal Beach Hotel, Southsea. Wed., 3 Dec., 7.30 p.m.

Institute of Marine Engineers

LONDON
"Modern Marine Water-Tube Boilers," by Lieut.-Commander A. P. Monk, R.N. (ret.). Student Lecture. Mon., 1 Dec., 6.30 p.m.*
"University Education in Marine Engineering," by Professor G. H. Chambers. Wed., 3 Dec., 5.30 p.m.*

Institute of Metals

LONDON
"Continuous Casting of Bronze," by Dr. E. C. Ellwood. London Local Section. Thurs., 4 Dec., 6.30 p.m.*
OXFORD
"Interplanetary Travel," by Dr. L. R. Shepherd. Oxford Local Section. Cadena Café, Cornmarket Street, Oxford. Tues., 2 Dec., 7 p.m.

Institute of Petroleum

LONDON
"Flow Properties of Distillates at Low Temperatures: A Review," by J. F. Hutton; and "The Pumpability of Aviation Turbine Fuels at Low Temperatures," by H. Strawson. Wed., 3 Dec., 5.30 p.m.*

Institute of Refrigeration

LONDON
"Moscow Meetings of the International Institute of Refrigeration: A Review," by G. L. H. Bird, Dr. J. C. Fidler, W. B. Gosney and Colonel H. Randal Steward. Institute of Marine Engineers, 76 Mark Lane, E.C.3. Thurs., 4 Dec., 5.30 p.m.*

Institute of Road Transport Engineers

CAMBRIDGE
"Costs and Costing Relating to the Operation and Maintenance of a Fleet of Vehicles," by W. J. Edbrooke. Eastern Centre. Golden Hind Hotel, Cambridge. Tues., 2 Dec., 7 p.m.

Institution of British Agricultural Engineers

LONDON
Discussion on "How Far Are British Tillage and Harvesting Machines Meeting Overseas Conditions?" Fri., 5 Dec., 2.15 p.m.

Institution of Chemical Engineers

MANCHESTER
"Wetted Area in Packed Towers," by W. S. Norman and B. Solomon. North Western Branch. Chemical Engineering Building, Manchester College of Science and Technology, Jackson Street, Manchester. Tues., 2 Dec., 6.30 p.m.

Institution of Civil Engineers

LONDON
"Shoreham Harbour Development," by H. Ridehalgh. Tues., 2 Dec., 5.30 p.m.*
MANCHESTER
"Recent Developments in Soil Mechanics as Applied to Road Construction," by S. Raymond. North Western Association. Engineers' Club, Albert Square, Manchester. Thurs., 4 Dec., 6.30 p.m.

Institution of Electrical Engineers and British Nuclear Energy Conference

LONDON
"A Review of Work Towards Nuclear Energy from Controlled Thermonuclear Reaction," by D. W. Fry. Institution of Electrical Engineers, Savoy Place, W.C.2. Thurs., 4 Dec., 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Power-System Automatic Frequency Control Techniques," by F. Moran. Joint Meeting of Measurement and Supply Sections. Tues., 2 Dec., 5.30 p.m.*
BIRMINGHAM
Various short papers. South Midland Centre. College of Technology, Gosta Green, Birmingham. Mon., 1 Dec., 6 p.m.*
Faraday Lecture on "Automation," by Dr. H. A. Thomas. South Midland Centre. Town Hall, Birmingham. Tues., 2 Dec., 7 p.m.
EDINBURGH
"Generation of Electricity in the London Area," by H. V. Pugh. South East Scotland Sub-centre. Carlton Hotel, North Bridge, Edinburgh. Tues., 2 Dec., 7 p.m.
HULL
"Organisation for Large-Scale Grid System Tests," by Dr. F. H. Last, E. Mills and N. D. Norris. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., 4 Dec., 6.30 p.m.
LEEDS
"Operational Experience at Calder Hall," by K. L. Stretch. North Midland Centre. Offices of the Central Electricity Generating Board, Leeds. Tues., 2 Dec., 6.30 p.m.
LEICESTER
Faraday Lecture on "Automation," by Dr. H. A. Thomas. East Midland Centre. De Montfort Hall, Leicester. Thurs., 4 Dec., 7.15 p.m.
MANCHESTER
"Thermonuclear Fusion and the Development of ZETA," by E. R. Hartill. North Western Centre. Engineers' Club, Manchester. Tues., 2 Dec., 6.15 p.m.

Institution of Electronics

PORTSMOUTH
"Applications of Transistors in Communications and Control Equipment," by E. Wolfendale. Southern Division. College of Technology Annexe, Anglesea Road, Portsmouth. Fri., 5 Dec., 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Discussion on "Alignment of Shafting." Tues., 2 Dec., 6.30 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Electrostatic Precipitation as Applied to the Heating and Ventilating Industry," by D. A. Bennell. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Wed., 3 Dec., 6 p.m.*
NOTTINGHAM
"Small Pipe Central Heating: Design, Installation and Cost," by D. V. Brook. East Midland Branch. College of Arts and Crafts, Waverley Street, Nottingham. Wed., 3 Dec., 6.30 p.m.

Institution of Highway Engineers

LONDON
"Motorway Design and Construction in Worcestershire," by W. R. Thomson. 11 Upper Belgrave Street, S.W.1. Fri., 5 Dec., 5.30 p.m.*

Institution of Mechanical Engineers and British Nuclear Energy Conference

LONDON
"Experimental Investigation into the Stress Distribution in a Band Reinforced Pressure Vessel," by K. G. Mantle, N. Marshall and P. J. Palmer. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Fri., 5 Dec., 6 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "Planning of Mechanical Engineering Teaching Laboratories." Education Group. Tues., 2 Dec., 6 p.m.*
ABERDEEN
"The Steam Catapult," by Commander C. C. Mitchell. Scottish Branch. Robert Gordon's College, Aberdeen. Fri., 5 Dec., 7.30 p.m.
MANCHESTER
"Design and Construction of the Compressor for the 8 ft by 8 ft RAE Wind Tunnel, Bedford," by L. J. Cheshire and others. North Western Branch. Engineers' Club, Manchester Thurs., 4 Dec., 6.45 p.m.
NEWCASTLE UPON TYNE
"Management Control and the Small Firm," by L. Fontaine, J. W. Walker and W. R. Spencer. North Eastern Branch, Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 1 Dec., 6 p.m.

Institution of Naval Architects

LONDON
"Design of Inflatable Life Rafts," by C. H. Latimer-Needham. Thurs., 4 Dec., 4.45 p.m.*

Institution of Production Engineers

BRISTOL
"Materials Handling: A Challenge to British Industry," by A. G. Hayek. Western Section. The University, Bristol. Wed., 3 Dec., 7.30 p.m.
READING
"The Value of the Consultant to Industry," by A. F. Masters. Reading Section. Great Western Hotel, Reading. Thurs., 4 Dec., 7.30 p.m.

Institution of the Rubber Industry

BURTON-ON-TRENT
"New Developments in Rubber," by S. C. Stokes. Burton-on-Trent Section. Midland Hotel, Station Street, Burton-on-Trent. Wed., 3 Dec., 7.30 p.m.

Institution of Structural Engineers

SHEFFIELD
"Precast Concrete Structures, Particularly Folded Slab Roof Construction," by F. J. Samuely. Yorkshire Branch. Royal Victoria Hotel, Sheffield. Wed., 3 Dec., 6.30 p.m.

Junior Institution of Engineers

LONDON
Film Evening. Fri., 5 Dec., 7 p.m.*

Leeds Metallurgical Society

LEEDS
"Thermodynamics in Metallurgy," by J. Lumsden. Chemistry Wing, The University, Leeds 2. Thurs., 4 Dec., 7.15 p.m.

Reinforced Concrete Association

MANCHESTER
"Precast Concrete in Framed Buildings," by E. S. Benson. North Western Branch. College of Technology, Sackville Street, Manchester. Mon., 1 Dec., 6.45 p.m.*

Royal Institution

LONDON
"Stellar Motions and the Structure of the Universe," by Dr. Richard van der Riet Woolley. Fri., 5 Dec., 9 p.m.

Royal Society

LONDON
Discussion on "Effect of Environment upon Molecular Energy Levels," opened by Dr. H. W. Thompson. Thurs., 4 Dec., 10.30 a.m.

Royal Society of Arts

LONDON
"Development of the Aeroplane," by Peter W. Brooks. Mon., 1 Dec., 6 p.m.
"The Consulting Engineer and His Contribution to the National Economy," by Julian S. Tritton. Wed., 3 Dec., 2.30 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Steelmaking in Small Furnaces," by T. A. Cosh. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 2 Dec., 7 p.m.

Society of Chemical Industry

LONDON
Three short papers. Tues., 2 Dec., 6.30 p.m.*

Society of Engineers

LONDON
"Some Industrial Applications of Magnetic Power," by T. J. Hawker. Geological Society, Burlington House, Piccadilly, W.1. Mon., 1 Dec., 5.30 p.m.*

Society of Instrument Technology

GRANGEMOUTH
Annual General Meeting. Grangemouth Section. Leapark Hotel, Grangemouth. Thurs., 4 Dec., 7 p.m.

Women's Engineering Society

LONDON
Discussion on "Helicopters." London Branch. Hope House, 45 Great Peter Street, S.W.1. Thurs., 4 Dec., 7 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this feature should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1. (TATe Gallery 9371.)
British Nuclear Energy Conference, Great George Street, London, S.W.1. (WHItehall 4577.)
Chemical Engineering Group, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 2 Grosvenor Gardens, London, S.W.1. (SLOane 0469.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave Square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, 61 New Cavendish Street, London, W.1. (LANgham 3583.)
Institute of Refrigeration, New Bridge Street House, New Bridge Street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham Gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Electronics, 78 Shaw Road, Thornham, Rochdale, Lancs. (Oldham Main 6661.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria Street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave Street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds.
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Institution, 21 Albemarle Street, London, W.1. (HYD Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865.)
Society of Chemical Industry, 14 Belgrave Square, London, S.W.1. (BELgrave 3681.)
Society of Engineers, 17 Victoria Street, London, S.W.1. (ABBey 7244.)
Society of Instrument Technology, 20 Queen Anne Street, London, W.1. (LANgham 4251.)
Women's Engineering Society, 25 Foubert's Place, London, W.1. (GERrard 5212.)

Metals and Materials

REINFORCED PLASTICS — 1958 AND BEYOND

Reinforced plastics are not in themselves new—paper and cotton phenolic laminates are almost as old as the plastics industry—but what we have come to call reinforced plastics during the last ten years are new, and are sometimes called structural plastics. They comprise a whole family of materials which gain their very high strength from strong fibres—generally glass or asbestos—combined with synthetic resins such as polyesters, low pressure phenolics, epoxides, or silicones. In this way plastics can achieve a strength and mechanical performance comparable with some metals, and rather better than timber.

Because reinforced plastics are so new the industry is in a constant state of flux. This means that data are apt to be unreliable, or not easily accessible. The designer has to gather scraps of information from literature or from raw material suppliers, and the moulder has to make his own tests, and establish his own standards. We have not yet arrived at the day when reinforced plastics achieve predictable, consistent properties so that safety factors, which are really factors of ignorance, can be reduced and the cost/strength ratio improved.

The rate of growth of the industry in Britain has been considerable—from about 300 tons in 1952 to somewhere between 7,000 and 8,000 tons this year, but as will be seen from these figures the consumption of reinforced plastics is still very small when viewed against the background of the whole plastics industry's output of over 300,000 tons. On 22 to 24 October, 1958, the British Plastics Federation held the Fourth Reinforced Plastics Technical Conference at Brighton, which was attended by nearly 400 delegates from all parts of the world. The following observations form the greater part of the summing up of the chairman, Mr. H. V. Blake, of Fibreglass Limited.

In dealing with the various sessions of the conference, Mr. Blake started with glass fibres: . . . The real problem is that no one has yet learned enough about them. It is clear that the surface condition of the fibre is of the utmost importance—perhaps more important than the diameter—and further research is clearly needed to maintain the phenomenal properties of glass fibres which may be realised in a vacuum. Perhaps you will begin to understand some of the problems involved when it is realised that even at this conference it is not clear what glass is. One speaker says it is a rigid liquid,[1] another says it is a brittle solid[2]; but whatever it is, its obviously high intrinsic properties can be extremely valuable in reinforced plastics, and the practical use of the very high theoretical strength is a problem that has still to be solved.

Fatigue and creep seem to be now one phase of investigation into glass/resin laminates that is showing some encouraging signs, and it appeared to be a favourable comparison which was made between the glass/resin material and the light alloy in long-term fatigue resistance.[2, 3] We learned, what we probably knew already, that glass laminates have a very human reaction—they dislike getting into hot water.[4] Here again, there is the comparison with the long-term hot water immersion of glass/resin laminates and the more traditional reinforced plastics such as cotton/paper/phenolics. Something will certainly have to be done about the drop in performance, but it should be realised that even when the drop has occurred, the properties still compare very favourably with those of many other materials.

The paper on flake-glass reinforced plastics[5] shows very clearly that there is a future for such materials where stiffness is of paramount importance. However it does appear that there are still some problems to be solved on the practical use of flakes, particularly in mixing them with the resin, and moulding on a practical commercial basis.

ELECTRICAL LAMINATES

Electrical laminates, of course, have been well known for many years, and in the two papers on them,[6, 7] the excellent electrical properties of silicone glass and epoxy glass were brought out. Different curing agents strike one as having a remarkable effect on the epoxy laminates.

The argument in favour of short-term tests in weathering of polyester and epoxy glass sheets was put forward most convincingly.[8] If we are going to get anywhere with reinforced plastics we are not going to be able to wait ten or twenty years every time we want to do a test.

I expect that we were all struck by the remarkably high temperature performance of asbestos reinforced plastics. The author of that paper[9] was probably right when he said that asbestos and glass are not really in competition. They are companion materials, and in many cases are used together in high temperature applications Glass gives the additional strength, and asbestos. and phenolic provide the cushion to take the thermal shock.

Papers have been presented on the application of reinforced plastics to chemical plant, sectional water tanks, building panels, lifeboats, and motor-car bodies[10, 11, 12]. Now all of these are successful applications for the material. They are well established and they are doing well. Particularly interesting were one speaker's comments about the reinforced plastics lifeboats and the savings mentioned of £2,000 a year on maintenance on a big passenger liner for lifeboats.[11] These are the sort of facts and figures that we don't often get. Our customers don't often tell us how good our material is. They generally tell us it is too expensive.

Building panels appear to offer a major use for this material and I understand that there is in

Continued on next page

SILICONE TREATMENT *for* BOTTLES

Resistance to breaking and bursting are two of the advantages claimed for glass bottles which have been surface-treated with silicones, about which there is much controversy at the present moment; at least so it seemed at a symposium held recently by the Society of Glass Technology. Stalemate between those for and against the treatment was ensured by the fact that nobody could decide what criterion should be used in assessing the performance of a bottle.

The main claim put forward for silicone surface-treatment is that it results in improved resistance to breakage, chipping and scratching, also that it can improve the bursting strength and the chemical durability of a bottle. Some would even go so far as to say that the appearance is improved, but this, surely, is purely a matter of personal taste. Silicones have rivals in this field of application, for instance, sulphur treatment is considered to be more effective for increasing the chemical resistance, and poly-oxyethylene monostearate is still an old faithful for preventing breakage and chipping. Perhaps, as with many new materials which appear to have many possible applications, there is a great deal of wishful thinking.

It is not fair to under-estimate the value of the research which is being put into this subject, but it does appear that the action of silicones in glass bottle manufacture is not yet fully understood and that such treatment will only be applied to full advantage when there is a full understanding of the basic physics and chemistry of glass surfaces.

STANDARD— STAINLESS STEEL

A new British Standard, 3014 : 1958, specifies requirements for "as welded" and cold-drawn welded tubes manufactured from austenitic stainles steel strip welded across the abutting edges throughout their length.

Tubes in the "as welded" condition are available in sizes from $\frac{3}{8}$ in up to $2\frac{1}{4}$ in outside diameter ($\frac{1}{8}$ in steps) and in thicknesses from 22 s.w.g. up to 12 s.w.g.

The standard contains a series of general requirements for test and inspection purposes. Specific requirements, such as delivery conditions and permissible variations in dimensions are given for each of the two types of tube. Copies may be obtained from the British Standards Institution, British Standards House, 2 Park Street, London, W.1. (*4s 6d*).

INTERNATIONAL POWDER METALLURGY GLOSSARY

To assist the development of powder metallurgy in various countries of the world, the journal *Metal Powder Report* will include, as a special supplement to forthcoming issues, a glossary or list of definitions of important terms used in powder metallurgy. It is intended to publish this glossary in all the principal European, Asian and African languages, including Afrikaans, Arabic, Chinese, Hebrew, Japanese, Persian, Russian Turkish and others. In each instance it is being prepared by a distinguished scientist or technologist in the country concerned. The journal is published monthly by Powder Metallurgy Limited, Berk House, Portman Square, London, W.1.

Continuing

Metals and Materials

fact a building now going up in this country which will be clad with glass/polyester resin panels. It will be interesting to see how that performs.

It was a very revealing picture that we were given yesterday of the way in which reinforced or even unreinforced epoxide resins have revolutionised tooling for pressed metal and, of course, are used for tools for reinforced plastics.[13, 14]

CRUDE METHODS IN MOULDING

There has always been considerable criticism of the reinforced plastics industry because of the crude methods that are used for moulding—the bucket and brush method for hand lay-up, and so on. I think some of this criticism has been a little unfair and misplaced, because there are some articles which can't really be made in any other way. They are not so bad as many people make out, and the inconsistencies of the mouldings are not so bad as is sometimes reported. But this, of course, does not mean that we do not want to see improvements. The Rand simultaneous resin and glass depositor at least goes part of the way towards mechanising the hand lay-up process[15]; and then there are pre-impregnated materials.[16] Now these are not really new, but almost certainly this is the first time they have been available on a large scale in this country and they should find ever increasing use. But, of course, neither of these two methods is really the final answer to all our mould ing problems. They are significant advances but we have still to find the magic method of making reinforced plastics quicker and better than pressed metal.

Further research and development will continue with, I hope and believe, renewed vigour as a result of this Conference, but co-operation is required for this work to go ahead. Now that we have a reinforced plastics group of the British Plastics Federation, this might at least help us to go ahead more quickly. However, research and technical development must be paid for, and the most successful way of doing that is to make the best commercial use of this material as it exists to-day.

REFERENCES

All references are to papers presented at the Conference, copies or further details of which may be obtained from the British Plastics Federation, 47-48 Piccadilly, London, W.1.

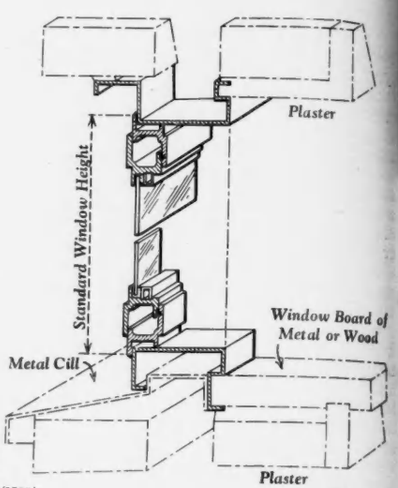
[1] Professor C. Gurney, "The Strength of Glass and Glass Fibres."
[2] Heywood, R. B., "The Present and Potential Fatigue Strength of Glass Reinforced Plastics."
[3] Thompson, A. W., "Further Work on the Fatigue and Creep Properties of Plastics Laminates."
[4] Brookfield, K. J., and Pickthall, D., "The Effect of Heat and Water Immersion on the Flexural Strength of Certain Glass Fibre/Polyester Resin Laminates."
[5] Rugger, G. R., "Development of Flake Glass Laminate."
[6] Davis, J. H., and Griffin, P. A., "The Flexural Strength and Electrical Properties of Silicone Glasscloth Laminates."
[7] Carey, J. E., and Hiron, F. P., "The Assessment of the Electrical Characteristics of 'Epikote' Resin/Fibreglass Laminates."
[8] Moss, W. H., "The Weather and Accelerated Weathering of Reinforced Plastics."
[9] Rosato, D. V., "Structural and Heat Resistant Asbestos Reinforced Plastics."
[10] Galt, G. S., "Glass Reinforced Plastics for Translucent Building Panels."
[11] Stevenson, W. J., "The Development of the Glass Reinforced Plastic Ships' Lifeboat."
[12] Hill, R. F., "Glass Reinforced Plastics for Motor-car Bodies."
[13] Pentz, P. G., "Tooling in Plastics."
[14] Dunn, P. A., and White, E. M., "Epoxy Resins in Glass Cloth Laminates for Tooling."
[15] Anderson, D. F., "The Rand Process of Simultaneous Deposition of Fibreglass and Resin."
[16] Cameron, J. B., and Kris, R., "Properties and Methods of Use of Pre-impregnated Reinforced Plastics."

Engineering at Home

ALUMINIUM CASEMENTS

Over the past ten years increasing use has been made of aluminium for window frames. A brochure, *Aluminium Windows*, published by the Aluminium Development Association, 33 Grosvenor Street London, W.1, provides a valuable summary of progress over these years and of current practice. It is intended primarily for architects and their clients, and for those concerned with installing aluminium windows. The price is 10*s* 6*d*.

Aluminium windows are offered in a large selection of styles and sizes, which harmonise with most colour schemes and architectural styles. This is well borne out in the first section of the brochure, "Types of Aluminium Windows." Made up largely of illustrations from photographs, many in full colour, the section shows a variety of buildings using different types of window. The buildings range from the New Bodleian Library, Oxford, to the Methodist Church, South Ruislip; from a bakery in Zürich to a private dwelling in Caterham. The types of windows shown include the various forms of casement, sash or pivoted and projected windows. At present, there is no British Standard for aluminium windows, but there is one for steel (BS 990 : 1945). However, although metal window manufacturers offer aluminium windows to this Standard, the section shapes designed for steel do not always make the most effective use of aluminium. It is intended that the brochure may be used as a basis of a code of practice in lieu of a British Standard.



A vertical section through a standard aluminium window imposed on to a typical metal sub-frame for an 11 in cavity brick wall. (5787)

The first section also deals with metal sub-frames, sub-cills for sub-frames, window cills, and window fittings. A vertical section through a standard aluminium window assembly imposed on a typical metal sub-frame for an 11 in cavity brick wall is shown alongside.

The second section of the brochure deals with materials and methods. Recommended aluminium alloys, that is, those with sufficient strength and resistance to corrosion, are listed, and the methods of joining and finishing are outlined. The choice of finish depends largely on the frequency of cleaning expected and the quality of surface required. "As manufactured," sometimes known as "mill finish," can be given various textures by mechanical or chemical methods, and clear lacquers or paints can be applied if required. Alternatively an anodic finish may be produced, which preserves the initial clean appearance; further treatment with one or two coats of clear methacrylate lacquer ensures retention of good appearance for several years, depending on atmospheric conditions.

Installation is the concern of the third section, which describes the methods adopted at points of contact between aluminium and other building materials, including masonry, wood, putty, and steel. The section also deals with methods of glazing.

The final section is concerned with weathering and maintenance, listing the weathering properties of uncleaned aluminium (extruded sections of H9 and H10 alloys) for various locations and for unanodised and anodised finishes. In appendixes to the brochure are illustrated single and universal casements to BS 990 : 1945, and examples of metal window terminology. There is also a brief statement of British Standards nomenclature.

INSULATING FLOOR HEATING

Electric floor heating is very much in the news these days for domestic, commercial and industrial premises. Advantage can be taken of lower-tariff electricity at night in the off-peak period and sufficient heat is stored in the structure to maintain an even temperature during the following day.

Heat leakage inevitably occurs at all points at which the floor is in contact with the building structure. The main loss is along the edge of the floor where contact is made with the walls or cladding. The Expanded Rubber Company Limited, Croydon, Surrey, have issued a leaflet dealing with this and describing their product "Onazote." Onazote is an edge insulant which, because of its low water absorbtion properties it is claimed, has a thermal conductivity that is constant at 0·20 Btu/sq. ft/hr/in/° F. It is an expanded ebonite having a cellular structure which is inert to fungoid or bacterial growth. Its specific weight is only 4 lb per cu. ft and it has a strength, in both compression and tension, of around 40 lb per sq. in. To effect edge insulation Onazote boards, usually 12 in wide, are located along the inside face of the wall with the top edge of the insulation almost level with the concrete floor.

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